MAP MF-1382-K

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MAPS SHOWING DISTRIBUTION OF ANOMALIES BASED ON THE USE OF R-MODE FACTOR ANALYSIS FOR SELECTED GROUPINGS OF ELEMENTS IN SAMPLES OF MINUS-60-MESH (0.25-MM) STREAM SEDIMENT AND NONMAGNETIC HEAVY-MINERAL CONCENTRATE, WALKER LAKE 1° X 2° QUADRANGLE, CALIFORNIA AND NEVADA

By M.A. Chaffee

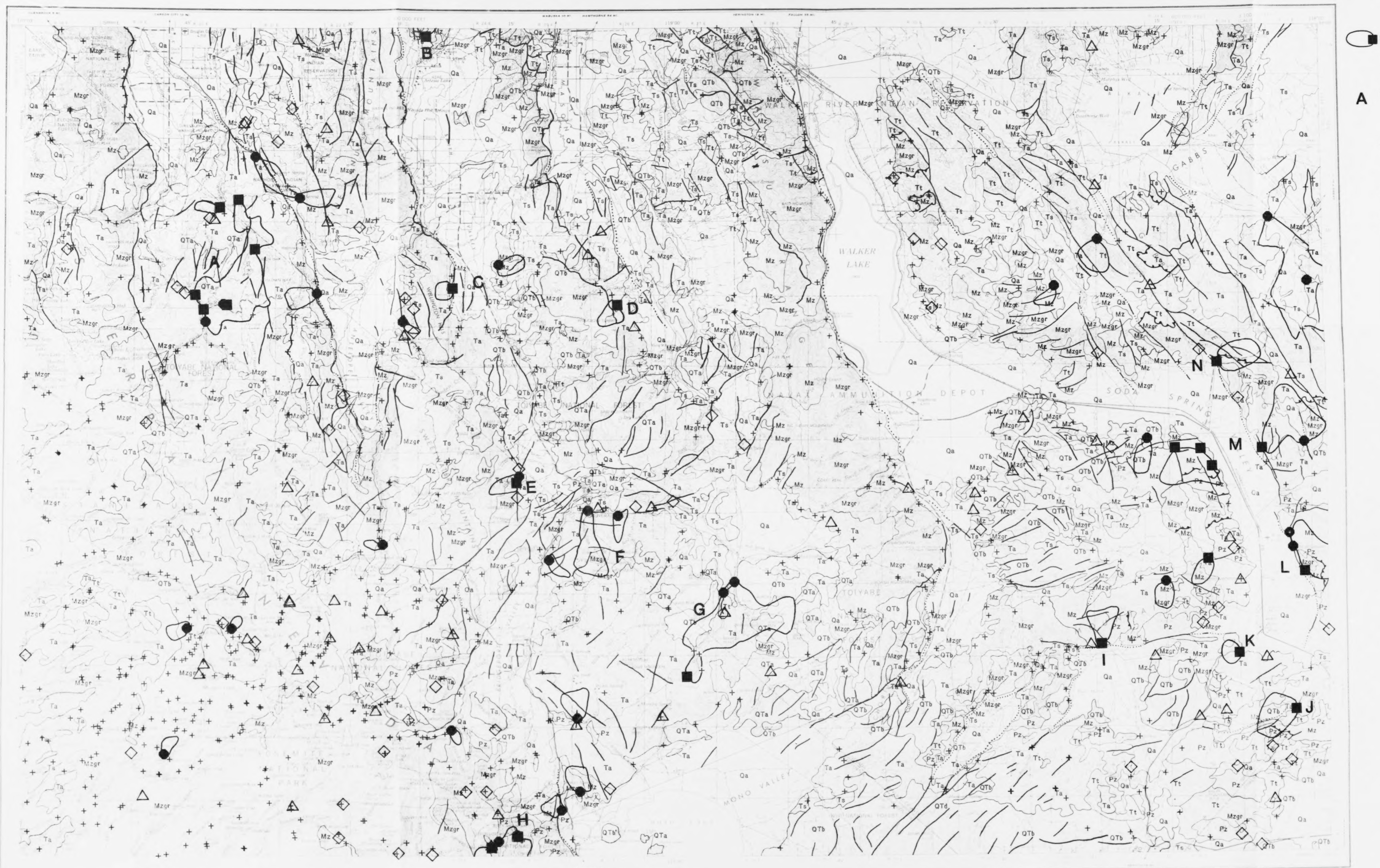
CHAFFEE—ANOMALIES BASED ON R-MODE FACTOR ANALYSIS, STREAM SEDIMENT AND NONMAGNETIC HEAVY-MINERAL CONCENTRATE, WALKER LAKE 1° X 2° QUAD, CA-NV 1:250,000 MAP MF-1382-K

NEW YORK
JUN 6 1989
STATE LIBRARY

MISCELLANEOUS FIELD STUDIES MAP
Published by the U.S. Geological Survey, 1988

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1382-K
SHEET 1 OF 2



EXPLANATION

■ SAMPLE LOCALITY AND BOUNDARY OF ASSOCIATED DRAINAGE BASIN--Anomalous for stream-sediment samples with significant loadings on factor 7. Locality is at center of plotted symbol. Square symbol indicates upper 2% of the data (98th percentile). Circle symbol is next 3%; diamond, next 5%; triangle, next 5%; and plus symbol (+), remaining 85%. Darkened symbols identify the most significant sites

A SIGNIFICANT ANOMALOUS AREA OR SITE--Letter is keyed to list in text

MAP A. DISTRIBUTION OF SITES FOR MINUS-60-MESH (0.25-MM) STREAM-SEDIMENT SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 7 OF AN 8-FACTOR R-MODE ANALYSIS

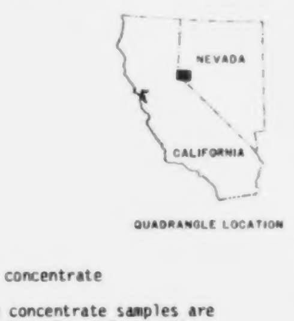
Geology simplified from Stewart and others, 1982

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



QUADRANGLE LOCATION

INTRODUCTION

This report is part of a folio of maps of the Walker Lake 1° x 2° quadrangle, California and Nevada, prepared under the Conterminous United States Mineral Assessment Program. The folio includes geological, geochemical, and geophysical maps, as well as mineral resource assessment maps, which identify known or possible selected mineral-deposit environments in the quadrangle. The geochemical maps show the distributions of selected individual elements (Chaffee and others, 1988a, b, c, d) and the distributions of selected groups of elements (Chaffee, 1988a, b). Discussions accompanying the individual element maps are restricted to possible mineral residences of the individual elements as well as to what types of mineral deposits and environments may be represented by anomalies of a particular element. Discussions accompanying the multielement maps describe the possible types of mineral deposits that may be related to each element group and indicate the most favorable localities for these deposits.

This chapter of the folio shows the distributions of elements grouped into selected factors by R-mode factor analysis, for 1,116 samples of minus-60-mesh (0.25-mm) stream sediment or 1,005 samples of nonmagnetic heavy-mineral concentrate derived from stream sediment.

Data for 110 stream-sediment samples and 3 concentrate samples included in this report are from samples collected and analyzed during 1967 and 1968 for the Emigrant Basin Primitive Area study (Tooker and others, 1970). The rest of the samples were collected and analyzed during 1978 and 1979, specifically for the present report. A combined tabulation of all these analyses is published as U.S. Geological Survey Open-File Report 80-881 (Chaffee and others, 1980). This same tabulation is also available on computer tape from the National Technical Information Service (McDanal and others, 1981).

GENERAL GEOLOGY

The Walker Lake quadrangle includes parts of two major physiographic provinces: the Sierra Nevada-Cascade Mountains and the Basin and Range provinces. These two provinces have contrasting geological frameworks that reflect their different geologic histories. Because the geology of the Walker Lake quadrangle is complex, only a brief generalized summary is given here.

Sierra Nevada-Cascade Mountains province

Most of the western one-third of the quadrangle is in the Sierra Nevada. The Sierra Nevada includes the major Sierra Nevada batholith, which is composed of plutons ranging from Permian(?) to Late Cretaceous in age (Keith and Seitz, 1981). These plutons range from alaskite to gabbro in composition, with the majority of the rocks being in the quartz monzonite to granodiorite range. This plutonic complex has intruded and metamorphosed a sequence of Paleozoic and Mesozoic rocks that comprise both clastic- and carbonate-rich sedimentary rocks as well as volcanic (and plutonic?) rocks. Overlying these older units locally are Tertiary volcanic rocks consisting of flows, breccias, and lahars, and intrusive dikes, sills, and necks. Most of these Tertiary volcanic rocks are andesitic in composition; however, rocks of rhyolitic composition are present locally. Glacial and landslide deposits are present locally in many of the valleys in the Sierra Nevada.

Basin and Range province

Most of the eastern two-thirds of the quadrangle is in the Basin and Range physiographic province. Much of this part of the quadrangle contains thick sequences of extensively block-faulted Paleozoic and Mesozoic sedimentary rocks of widely varying compositions. Mesozoic plutons, which range in composition from alaskite to gabbro but are predominantly in the granite to granodiorite range, have intruded and locally metamorphosed the overlying sedimentary rocks. A long history of Tertiary volcanism is recorded in the eastern part of the quadrangle; thick sequences of flows, breccias, and tuffs, ranging in composition from rhyolite to basalt, are found throughout much of the area. Tertiary clastic sedimentary rocks were deposited in some areas. Tertiary and Quaternary volcanic flows, breccias, and shallow intrusive rocks, ranging in composition from rhyolite to basalt, are also present locally. Alluvial, lacustrine, and eolian sedimentary deposits are present in most of the valleys in this part of the quadrangle.

Geologic base for the geochemical maps

A simplified geologic base map of the Walker Lake quadrangle has been used with each of the accompanying geochemical maps. A more detailed geologic map of the quadrangle is available as a separate chapter in this Walker Lake folio (Stewart and others, 1982). For purposes of discussion in this report, some of the geologic units shown on the geologic map of Stewart and others (1982) have been consolidated into three major units.

Paleozoic and Mesozoic rocks--All of the pre-Cretaceous (Paleozoic and Mesozoic) igneous and sedimentary rock units (units Pz and Mz on map) have been consolidated into this one unit. Many but not all of these rocks have been metamorphosed.

Mesozoic intrusive rocks--Plutons ranging in composition from alaskite to gabbro compose this unit (unit Mzgr on map).

Tertiary volcanic rocks--This unit is composed predominantly of flow rocks of andesitic composition, but it also includes necks and flows ranging in composition from rhyolite to basalt as well as felsic to intermediate tuffs (includes units Tt and Ta on map).

ECONOMIC GEOLOGY

Many anomalies shown on the accompanying maps are related to known mining activity. Some known mineral deposits are not reflected by anomalies, however, primarily because they are not close to sampled stream channels but also because not all samples collected were truly representative of the material being eroded upstream from the sample site. Because the sampling was designed and executed on a reconnaissance scale, some relatively small but exposed areas of anomalous rock may not have been detected despite proximity to sampled stream channels. Mineral deposits not exposed at the surface may not be easily detected even if part of the deposit system, such as an alteration aureole, is exposed. Additional detailed geochemical surveys would be necessary to identify and delineate specific mineralized areas.

Deposits of both placer minerals and saline, playa-associated minerals have been mined in the past in many of the alluvium-filled valleys and basins scattered throughout the Walker Lake quadrangle. The sampling program for the present study was designed primarily to evaluate areas of outcrop; thus, mineral deposits that may be present in alluvial-filled valleys and basins are excluded from consideration in this geochemical report.

DESCRIPTION OF THE SAMPLE MEDIA

Sediment was collected from active stream channels and processed to produce the minus-60-mesh stream-sediment and the nonmagnetic heavy-mineral-concentrate samples. Unlike rock samples, which represent a restricted, essentially point source, the sediment collected at a given site is considered to represent a composite of outcrop material eroded from the entire drainage basin upstream from the collection site.

The stream-sediment samples provide information about the elements in all of the minerals present in the eroded rock materials. In contrast, the concentrate samples provide information about the elements in only a limited number of minerals. The concentrating process removes most of the quartz, feldspar, clay minerals, and highly magnetic minerals. This selective concentration of minerals commonly related to mineral deposits permits determination of some elements that are not commonly detected in stream-sediment samples by emission spectroscopy. The concentrate chemistry may also be specific for certain minerals. For example, the concentration of barium in a stream-sediment sample represents the sum of barium contained in barite plus barium contained in potassium feldspars and possibly other minerals. Because of the processing procedures used, the barium in a concentrate sample represents predominantly the single mineral barite.

SAMPLE PREPARATION AND ANALYSIS

Sample preparation

The stream-sediment samples were composited from active alluvium collected from several locations within a 50-ft (15-m) radius of the localities shown on the accompanying maps. Each resulting sample was air-dried and then sieved. The material passing a screen with 0.25-mm openings (a 60-mesh screen) was saved and pulverized.

The concentrate samples were processed from the same composited active alluvium material collected for the minus-60-mesh stream-sediment samples. The material was wet-panned until most of the quartz, feldspar, organic material, and clay-sized material was removed. The samples were air-dried, and the highly magnetic material was removed using a magnet. Any light material remaining in the concentrate was then separated by allowing the heavier fraction of the sample to settle through bromoform (specific gravity 2.86). The resulting heavy-mineral fraction was then separated into a magnetic and a relatively nonmagnetic fraction using a Frantz Isodynamic Separator[2] set at 0.6 amperes, with 15° forward and 15° side settings. The resulting nonmagnetic fraction was pulverized in an agate mortar.

Sample analysis

Both stream-sediment and nonmagnetic heavy-mineral-concentrate samples were analyzed for 31 elements (Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, and Zr) using a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). Because of the limited amount of sample material, the concentrate samples were only analyzed spectrographically. The stream-sediment samples were also analyzed for arsenic by colorimetry (Ward and others, 1963), for zinc, antimony, and gold by atomic-absorption spectrometry (Ward and others, 1969; Welsch and Chao, 1975; Meier, 1980), and for cadmium and bismuth from a single solution by atomic-absorption spectrometry (Viets, 1978). Analyses for both sample types were performed partly in the field in a mobile chemistry laboratory and partly in U.S. Geological Survey laboratories near Golden, Colo.

The spectrographic analytical values are reported as the approximate geometric midpoints (0.15, 0.2, 0.3, 0.5, 0.7, and 1.0, or appropriate powers of ten of these values) of concentration ranges whose respective boundaries are 0.12, 0.18, 0.26, 0.38, 0.56, 0.83, and 1.2 (or appropriate powers of ten of these values). In general, the precision of the spectrographic method is plus or minus one reporting value of the value given by the analyst approximately 83 percent of the time and plus or minus two reporting values of the value given by the analyst 96 percent of the time (Motooka and Grimes, 1976). A reference standard sample was analyzed with each batch of field samples to monitor the quality of the analyses.

For the six elements analyzed by colorimetry or atomic-absorption spectrometry, the reporting values vary with the element and with the concentration level for any given element. Precision for these analytical methods is commonly reported as a percent relative standard deviation and is based on replicate analyses of samples selected to provide information at

DISCUSSION OF R-MODE FACTOR ANALYSIS

Factor analysis is a mathematical technique that is widely used to identify common groups, or factors, of the variables in a data set, based on the variation in correlation coefficients of the variables. The technique is particularly suited to evaluations of large data sets, such as those created for the geochemical study of the Walker Lake quadrangle. R-mode factor analysis, as used for this report, objectively groups chemical elements that vary sympathetically in samples into a set of factors, containing one or more of the original elements. Ideally, R-mode factor analysis can be used subjectively by the interpreter to identify factors representing groups of elements that may have a common association that can be related to known or inferred geologic conditions in the study area. Factors representing felsic rock-forming elements, precious-metal-associated elements, alteration-aureole-associated elements, and so on, may be present. Other factors in the same factor model may have no obvious relationship to geologic conditions and can be ignored.

In factor analysis individual elements are often components of more than one factor. The relative degree with which a given element correlates with a given factor is called its factor loading value. Within each factor, the relative degree with which each sample correlates with the factor is called its factor score. The factor scores created by the R-mode program used for this study range in value from -1.0 to +1.0; the sample having the +1.0 value (the end member) is considered the most significant for a given factor in terms of identifying mineralized localities. Thus, the closer the factor score for a given sample is to +1.0, the more favorable is the locality represented by that sample for being similar chemically to the sample with the +1.0 factor score.

For the geochemical study of the Walker Lake quadrangle, the principal components extracted in the R-mode factor analysis were rotated according to an oblique solution available in the U.S. Geological Survey STATPAC library (VanTrump and Miesch, 1977). This solution was selected because it tends to emphasize the extreme values (end members) in a data set; these extreme values tend to be related to mineralization.

For further details of applications of R-mode factor analysis to the evaluation of geologic problems, the reader may wish to consult reference books, such as Davis (1973).

APPLICATION OF R-MODE FACTOR ANALYSIS TO THE CHEMICAL ANALYSES

For the geochemical study of the Walker Lake quadrangle, elements having a high percentage (generally above 90 percent) of qualified values (values listed by the analyst as "G" (greater than) or "L" (less than) some limiting value or as "N" (not detected" at some lower limit of determination)) were deleted from the data set used in the factor-analysis program. For this report 10 elements (As, Au, Bi, Cd, Nb, Sb, Sn, Th, W, and Zn) were deleted from the data set because of an excessively high percentage of qualified values in spectrographic analyses of stream-sediment samples. Six elements (As, Au, Bi, Cd, Sb, and Zn) were deleted because of an excessively high percentage of qualified values in spectrographic analyses of concentrate samples. Because gold was determined by atomic-absorption spectroscopy in only about 10 percent of the stream-sediment samples, it, too, was deleted from the stream-sediment data set.

For those remaining elements (tables 2 and 3) logical unqualified values were substituted for the qualified values. Where such substituting was done, the values assigned for "greater than" or "less than" a limiting value are one standard reporting value above or below the limiting value, respectively. For those samples reported by the analyst as "not detected" at some lower limit of determination, the substituted value was three standard reporting values below the lower limit of determination. The analytical values for most of the ore-related elements studied for this report were found to most closely approximate lognormal distributions. Thus, after substitutions were made, the analyses were converted to logarithms.

For this report the 8-factor models for both the stream-sediment and concentrate data sets were selected as the ones that seemed to best fit known or expected types of mineralization in the Walker Lake quadrangle. The 8-factor model accounts for 74 percent of the overall data variability for both the stream-sediment samples and the concentrate samples. On the basis of the plan to concentrate on locating specific types of mineral deposits, one factor was chosen from the 8-factor model of the stream sediment and three factors were chosen from the 8-factor model of the concentrate samples for plotting for this chapter of the folio. The complete lists of values for the factor loadings for the two selected models are given in tables 4 and 5.

For the map plots, the samples were arranged by their factor scores in descending order from +1.0 to -1.0 and were then assigned to class intervals that were arbitrarily divided at approximately the 85th, 90th, 95th, and 98th percentiles. Map symbols were then assigned to each class and plots were made using the symbols shown on the respective maps in this chapter of the folio.

The Walker Lake quadrangle contains a large variety of known or suspected mineral deposit types. Many ore-related elements are probably associated with more than one type of mineral deposit; in addition, many of these same elements, especially in the stream-sediment samples, may be enriched in common rock-forming minerals such as feldspars, micas, and amphiboles. Because of these associations, the results of the R-mode factor analysis are often difficult to interpret in terms of deposit types.

DISCUSSION OF THE MAPS

Factor map for minus-60-mesh stream sediment

Only factor 7 of the 8-factor model for the stream-sediment samples is

Factor maps for nonmagnetic heavy-mineral concentrate

Factors 4, 6, and 7 of the 8-factor model for the concentrate samples are considered to be related to mineralization (table 5). Maps B and C show the distributions of anomalies based on factors 4 and 6. The loadings on factor 4 include, in order of importance from highest to lowest, the elements silver, lead, molybdenum, copper, tungsten, and tin (table 5). This factor is interpreted to represent an element suite that should be a useful guide to porphyry molybdenum deposits as well as to contact-metasomatic deposits of tungsten and base and precious metals. The sample with the factor score of +1.0 for this factor is from the Silverado district (area C on map B), a precious-metal district that may also contain molybdenum deposits. The upper 5 percent of the samples in the concentrate data set have been arbitrarily selected as anomalous. The most significant sites and areas, as identified by the R-mode factor analysis program, are (A) the southern end of the Pine Nut Mountains, (B) the Pine Grove district in the Pine Grove Hills, (C) the Silverado district in the Sweetwater Mountains, (D) the Bodie and Aurora districts in the Bodie Hills, (E) the area between Virginia Lakes, Lundy Canyon, and Conway Summit northwest of Mono Lake, (F) the Corey Peak area in the central Wassuk Mountains, (G) the Buller Mountain area in the southern Wassuk Mountains, (I) the Eastside mine area south of Teels Marsh, (J) the Candelaria district in the Candelaria Hills, (K) the south-central Excelsior Mountains north of Marietta, (L) the Camp Douglas-Thunder Mountain area at the east end of the Excelsior Mountains, and (M) the area on the north side of Mable Mountain in the Garfield Hills. The anomaly at site (H) is probably related to contamination associated with scrap metals placed in that area by personnel of the Hawthorne Army Ammunition Depot.

Most of the significant sites described above are associated either with the Paleozoic and Mesozoic rocks or with the Tertiary volcanic rocks, especially where either of these major assemblages is in the vicinity of Mesozoic intrusive rocks. Porphyry-type molybdenum deposits normally are contained within one or more intrusive rock units; however, here any porphyry-type molybdenum deposits in the areas associated with the sites described above are not likely to be exposed. Any contact-metasomatic deposits, on the other hand, probably are exposed.

Map C shows the distributions of anomalies based on factor 6 of the 8-factor model. The loadings on this factor include, in order of importance from highest to lowest, the elements copper, lead, cobalt, silver, iron, strontium, and barium (table 5). This factor contains the elements iron, cobalt, barium, and strontium that commonly occur in the Walker Lake quadrangle in areas of hydrothermal alteration accompanied by strong pyritization, particularly in Tertiary volcanic rocks. The copper, lead, and silver contribution to the factor probably is associated with base- and precious-metal mineralization related to vein deposits or possibly with concealed porphyry copper-type mineralization. The sample with the factor score of +1.0 for factor 6 is from the Monitor district (area A on map C), a precious-metal district that may also contain base metals.

The upper 10 percent of the samples in the concentrate data set have been arbitrarily selected as anomalous. The most significant sites and areas, as identified by the R-mode factor analysis program, are (A) the Monitor-Silver Creek area and the zone extending northeast from there to the southern Pine Nut Mountains; (B) the north end of the Wellington Hills; (C) the Relief Peak-Leavitt Peak area in the Sierra Nevada, (D) the area between Eagle Peak and Twin Lakes southwest of Bridgeport Valley; (E) the area between Lundy Canyon and Conway Summit, northwest of Mono Lake; (F) the south-central Excelsior Mountains north of Marietta; (G) the southern Miller Mountain area; (H) the Candelaria district in the Candelaria Hills; (I) a large area including the eastern Garfield Hills, the southern Gabbs Valley Range, and the western Pilot Mountains; (J) the north end of the Gabbs Valley Range; and (K) the Cottonwood Creek area in the central Wassuk Mountains. Most of the significant sites described above are associated either with the Paleozoic and Mesozoic rocks or with the Tertiary volcanic rocks.

Map D shows the distribution of anomalies based on factor 7 of the 8-factor model. The loadings on this factor include, in order of importance from highest to lowest, the elements tungsten, beryllium, manganese, boron, calcium, iron, and molybdenum (table 5). This factor contains a suite of elements that most likely represents contact-metasomatic tungsten deposits but might also locate areas favorable for porphyry molybdenum deposits. The sample with the factor score of +1.0 for this factor is from the Twin Lakes area, southwest of Bridgeport in the Sierra Nevada (area B on map D), an area containing contact-metasomatic tungsten deposits and locally containing precious metals.

The upper 5 percent of all of the samples in the concentrate data set have been arbitrarily selected as anomalous. The most significant sites and areas, as identified by the R-mode factor analysis program, are (A) the southern Pine Nut Mountains, (B) the large area between the Little Walker River and Lundy Canyon in the Sierra Nevada, (C) the Red Wash Creek area east of the Masonic district, (D) the Cottonwood Creek area near Buller Mountain in the southern Wassuk Mountains, (E) an area south of Miller Mountain near the southeastern corner of the quadrangle, (F) the eastern part of the Garfield Hills, (G) an area northwest of Gabbs Valley near the northern edge of the quadrangle, and (H) the area along the east side of the northern Wassuk Mountains.

Most of the significant sites described above are located in either the Paleozoic and Mesozoic rocks or the Mesozoic intrusive rocks, and, generally, where these two rock assemblages are in close proximity. This geologic setting is readily permissible for the typical environment for contact-metasomatic tungsten deposits.

For all of the maps in this part of the folio there is no assurance that all of the anomalies identify known or unknown mineral deposits or that all of the deposits in the categories thought to be represented by each map have in

REFERENCES

Chaffee, M.A., 1988a, Distributions of anomalies based on the use of SCORESUM plots for selected groupings of elements in samples of minus-60-mesh (0.25-mm) stream sediment, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-L, scale 1:250,000.

_____1988b, Distributions of anomalies based on the use of SCORESUM plots for selected groupings of elements in samples of nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-M, scale 1:250,000.

Chaffee, M.A., Hill, R.H., Speckman, W.S., and Sutley, S.J., 1980, Preliminary data set containing geochemical analyses of samples of rock, stream sediment, and nonmagnetic heavy-mineral concentrate, Walker Lake 2° quadrangle, California and Nevada: U.S. Geological Survey Open-File Report 80-881, 235 p.

Chaffee, M.A., Hill, R.H., and Sutley, S.J., 1988a, Distributions of copper, lead, zinc, cadmium, and silver in samples of minus-60-mesh (0.25-mm) stream sediment and nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Miscellaneous Field Studies Map MF-1382-G, scale 1:250,000.

_____1988b, Distributions of molybdenum, tin, boron, tungsten, and gold in samples of minus-60-mesh (0.25-mm) stream sediment and (or) nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-H, scale 1:250,000.

_____1988c, Distributions of iron, cobalt, barium, strontium, arsenic, antimony, and bismuth in samples of minus-60-mesh (0.25-mm) stream sediment and (or) nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-I, scale 1:250,000.

_____1988d, Distributions of 12 selected elements in samples of rock, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-J, scale 1:250,000.

Davis, J.C., 1973, Statistics and data analysis in geology: New York, John Wiley and Sons, 550 p.

Durham, D.L., and Felmlee, J.K., 1982, National uranium resource evaluation, Walker Lake quadrangle, California and Nevada: U.S. Department of Energy, Grand Junction Office, Open-File Report PGJ/F-010(82).

Fay, W.M., and Jones, P.L., 1980, Hydrochemical and stream sediment reconnaissance, Walker Lake 1° x 2° NTMS Area, California and Nevada: U.S. Department of Energy Report DPST-79-146-13, 51 p., 10 plates, 6 microfiche.

Grimes, D.J., and Marranzino, A.P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

McDanal, S.K., Speckman, W.S., and Chaffee, M.A., 1981, Spectrographic and chemical analyses of rock, stream-sediment, and concentrate samples from the Walker Lake 2° quadrangle, California and Nevada: available as a magnetic tape from National Technical Information Service, Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Meier, A.L., 1980, Flameless atomic-absorption determination of gold in geological materials: Journal of Geochemical Exploration, v. 13, no. 1, p. 77-85.

Stewart, J.H., Carlson, J.E., and Johannesen, D.C., 1982, Geologic map of the Walker Lake 1° x 2° quadrangle, U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-A, scale 1:250,000.

Tooker, E.W., Morris, H.T., and Fillo, P.V., 1970, Mineral resources of the Emigrant Basin Primitive Area, California, with a section on Geophysical studies, by H. W. Oliver: U.S. Geological Survey Bulletin 1261-G, 70 p.

VanTrump, George, and Miesch, A.T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geosciences, v. 3, p. 479-488.

Viets, J.G., 1978, Determination of silver, bismuth, cadmium, copper, lead, and zinc in geologic materials by atomic absorption spectrometry with tricaprylylmethylammonium chloride: Analytical Chemistry, v. 50, no. 8, p. 1097-1101.

Ward, F.N., Lakin, H.W., Canney, F.C., and others, 1963, Analytical methods used in geochemical exploration by the U.S. Geological Survey: U.S. Geological Survey Bulletin 1152, 100 p.

Ward, F.N., Nakagawa, H.M., Harms, T.M., and VanSickle, G.H., 1969, Atomic-absorption methods of analysis useful in geochemical exploration: U.S. Geological Survey Bulletin 1289, 45 p.

Welsch, E.P., and Chao, T.T., 1975, Determination of trace amounts of antimony in geological materials by atomic absorption spectrometry: Analytical Chimica Acta, v. 76, p. 65-69.

DESCRIPTION OF MAP UNITS

Qa ALLUVIAL, LACUSTRINE, EOLIAN, LANDSLIDE, AND GLACIAL DEPOSITS, UNDIVIDED (QUATERNARY)--As mapped locally includes uppermost Tertiary gravel

QTb BASALT (QUATERNARY AND TERTIARY)--Ranges in age from about

Table 1.--Lower and upper limits of analytical determination for samples of minus-60-mesh (0.25-mm) stream sediment and nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle

[(--) indicates not applicable. "aa" following the element symbol indicates atomic absorption analysis; "cm" indicates colorimetric analysis; no suffix indicates spectrographic analysis. The values listed for Fe, Mg, Ca, and Ti are in percent; all others are in parts per million]

Element	Stream sediment Lower	Stream sediment Upper	Nonmagnetic heavy-mineral concentrate Lower	Nonmagnetic heavy-mineral concentrate Upper
Ag	0.5	--	1.0	--
As	200	--	500	--
Au	10	--	20	1,000
B	10	--	20	5,000
Ba	20	--	50	10,000
Be	1	--	2	--
Bi	10	--	20	--
Ca	0.05	--	0.1	--
Cd	20	--	50	--
Co	5	--	10	--
Cr	10	--	20	--
Cu	5	--	10	--
Fe	0.05	--	0.1	20
La	20	--	50	2,000
Mg	0.02	--	0.05	--
Mn	10	5,000	20	--
Mo	5	--	10	--
Nb	20	--	50	--
Ni	5	--	10	--
Pb	10	--	20	--
Sb	100	--	200	--
Sc	5	--	10	--
Sn	10	--	20	--
Sr	100	--	200	10,000
Th	200	--	500	5,000
Ti	0.002	1.0	0.005	2.0
V	10	--	20	--
W	50	--	100	--
Y	10	--	20	--
Zn	200	--	500	--
Zr	10	1,000	20	2,000
As-cm	10	400	--	--
Au-aa	0.005	--	--	--
Bi-aa	0.5	--	--	--
Cd-aa	0.05	--	--	--
Sb-aa	1.0	--	--	--
Zn-aa	5		--	--

Table 2.--Summary of the number of qualified and unqualified analyses for selected elements in 1,116 samples of minus-60-mesh stream sediment

["N" indicates not detected at the lower limit of determination shown in table 1. "L" indicates detected but in a concentration below the lower limit of determination shown in table 1. "G" indicates detected but in a concentration greater than the upper limit of determination shown in table 1. "B" indicates samples not analyzed. "aa" following the element symbol indicates atomic absorption analysis; "cm" indicates colorimetric analysis; no suffix indicates spectrographic analysis]

Element	Number of unqualified samples	Qualified samples: Number of N	Number of L	Number of G	Number of B
Ag	90	970	56	0	0
B	1,011	50	47	0	8
Ba	1,116	0	0	0	0
Be	1,015	8	93	0	0
Ca	1,116	0	0	0	0
Co	1,055	28	33	0	0
Cr	1,020	8	88	0	0
Cu	1,071	4	41	0	0
Fe	1,115	0	0	1	0
La	1,055	32	29	0	0
Mg	1,116	0	0	0	0
Mn	1,115	0	0	1	0
Mo	306	697	113	0	0
Ni	955	53	108	0	0
Pb	1,103	3	10	0	0
Sc	1,065	9	34	0	8
Sr	1,114	0	2	0	0
Ti	1,113	0	0	3	0
V	1,116	0	0	0	0
Y	1,053	8	55	0	0
Zr	1,110	0	0	6	0
As-cm	111	749	145	1	110
Bi-aa	429	247	330	0	110
Cd-aa	805	60	141	0	110
Sb-aa	947	4	55	0	110
Zn-aa	1,068	0	0	0	48

Table 3.--Summary of the number of qualified and unqualified analyses for selected elements in 1,006 samples of heavy-mineral concentrate

["N" indicates not detected at the lower limit of determination shown in table 1. "L" indicates detected but in a concentration below the lower limit of determination shown in table 1. "G" indicates detected but in a concentration greater than the upper limit of determination shown in table 1. "B" indicates samples not analyzed]

Element	Number of unqualified samples	Qualified samples: Number of N	Number of L	Number of G	Number of B
Ag	88	911	6	0	0
B	697	182	123	2	1
Ba	891	4	21	89	0
Be	272	394	339	0	0
Ca	1,005	0	0	0	0
Co	773	74	158	0	0
Cr	948	9	48	0	0
Cu	637	107	261	0	0
Fe	1,002	0	2	1	0
La	983	1	12	9	0
Mg	999	0	6	0	0
Mn	1,005	0	0	0	0
Mo	521	325	159	0	0
Nb	718	82	205	0	0
Ni	497	238	270	0	0
Pb	843	92	70	0	0
Sc	996	0	8		1
Sn	690	235	80	0	0
Sr	826	123	54	2	0
Th	502	201	232	67	3
Ti	497	0	0	508	0
V	1,004	0	1	0	0
W	194	704	107	0	0
Y	1,003	0	2	0	0
Zr	456	0	0	549	0

Table 4.--Values for factor loadings for the 8-factor model using oblique rotation for samples of minus-60-mesh stream sediment

["aa" following the element symbol indicates atomic absorption analysis; "cm" indicates colorimetric analysis; no suffix indicates spectrographic analysis]

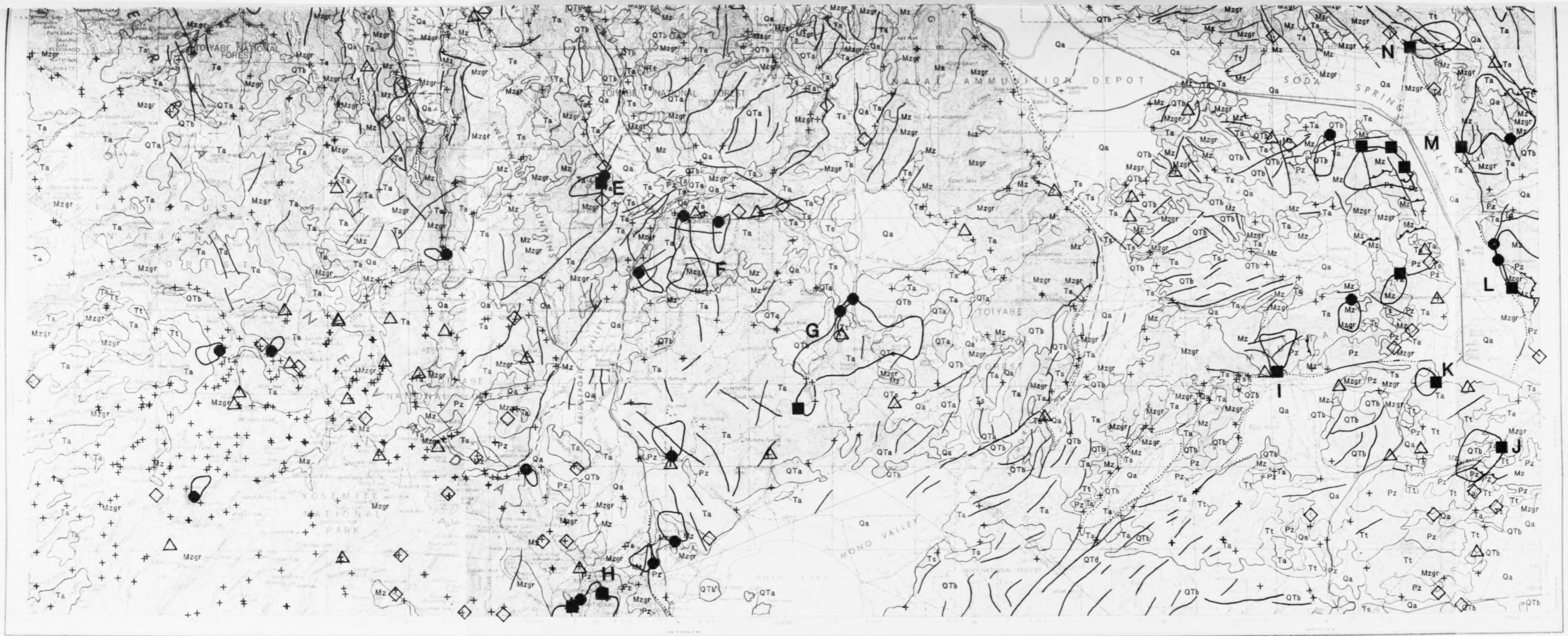
Element	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	FACTOR 7	Factor 8
Ag	0.32	0.08	-1.65	3.03	1.45	0.17	8.37	0.92
B	-2.24	-2.60	-0.52	1.13	0.36	0.33	3.66	0.09
Ba	-2.63	-0.57	0.67	-1.13	-2.15	0.67	2.26	-1.57
Be	-1.18	-1.58	-1.08	-0.84	0.37	0.84	1.52	0.10
Ca	-2.62	-1.28	0.97	-3.00	-2.60	0.34	-1.22	-1.79
Co	-1.13	-2.48	1.90	1.21	-2.18	0.24	0.76	-0.48
Cr	-1.57	-2.95	1.51	0.82	-1.43	-0.93	1.77	-0.95
Cu	-0.80	-1.69	1.45	1.77	-1.56	1.12	3.24	-0.13
Fe	0.40	-2.15	-0.01	-0.06	-2.90	0.71	0.78	-0.75
La	0.21	-3.18	-0.30	-0.34	0.68	0.05	0.87	0.69
Mg	-2.49	-2.59	1.64	0.37	-2.41	0.12	-0.68	-0.54
Mn	-0.24	-3.62	-0.14	1.24	-0.46	0.39	1.86	1.16
Mo	-0.94	-0.71	-0.65	2.01	0.50	0.54	0.40	3.12
Ni	-2.25	-2.32	1.93	0.72	-1.32	-0.83	2.25	-1.00
Pb	-0.01	-2.46	0.33	1.19	1.78	-0.09	5.91	1.53
Sc	-1.33	-3.28	1.56	1.39	-2.00	-0.25	-0.73	0.38
Sr	-2.24	-0.74	2.68	-5.22	-2.98	-1.12	-0.14	-2.33
Ti	0.07	-3.00	0.54	-0.82	-2.94	-0.46	0.57	-0.19
V	-0.32	-3.44	0.06	0.36	-2.01	0.15	1.50	-0.23
Y	0.12	-3.53	-0.64	1.74	-0.07	0.53	0.24	1.30
Zr	-0.01	-2.22	-1.14	-0.37	-1.67	0.90	0.26	-0.57
As-cm	-0.33	-0.34	-1.03	2.07	0.61	0.51	7.98	0.71
Bi-aa	0.56	0.61	1.29	-0.07	0.23	2.85	-0.66	-0.24
Cd-aa	0.34	0.79	0.33	0.52	-1.81	1.09	5.16	1.50
Sb-aa	-0.73	0.64	-3.03	1.45	0.15	-0.08	8.95	-2.49
Zn-aa	0.99	-0.47	0.46	1.21	-2.49	0.67	5.70	1.41

Table 5.--Values for factor loadings for the 8-factor model using oblique rotation for samples of nonmagnetic heavy-mineral concentrate

[All analyses are by emission spectroscopy]

Element	Factor 1	Factor 2	Factor 3	FACTOR 4	Factor 5	FACTOR 6	FACTOR 7	Factor 8
Ag	-0.02	0.27	1.88	6.00	1.19	2.66	0.55	-0.56
B	-1.63	-0.71	1.72	1.01	-0.62	-0.49	1.67	-0.69
Ba	-1.33	0.49	2.40	1.21	-0.91	1.37	0.22	2.25

best copy available



Geology simplified from Stewart and others, 1982

MAP A. DISTRIBUTION OF SITES FOR MINUS-60-MESH (0.25-MM) STREAM-SEDIMENT SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 7 OF AN 8-FACTOR R-MODE ANALYSIS

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

NEVADA
CALIFORNIA

QUADRANGLE LOCATION

INTRODUCTION

This report is part of a folio of maps of the Walker Lake 1° x 2° quadrangle, California and Nevada, prepared under the Conterminous United States Mineral Assessment Program. The folio includes geological, geochemical, and geophysical maps, as well as mineral resource assessment maps, which identify known or possible selected mineral-deposit environments in the quadrangle. The geochemical maps show the distributions of selected individual elements (Chaffee and others, 1988a, b, c, d) and the distributions of selected groups of elements (Chaffee, 1988a, b). Discussions accompanying the individual element maps are restricted to possible mineral residences of the individual elements as well as to what types of mineral deposits and environments may be represented by anomalies of a particular element. Discussions accompanying the multielement maps describe the possible types of mineral deposits that may be related to each element group and indicate the most favorable localities for these deposits.

This chapter of the folio shows the distributions of elements grouped into selected factors by R-mode factor analysis, for 1,116 samples of minus-60-mesh (0.25-mm) stream sediment or 1,005 samples of nonmagnetic heavy-mineral concentrate derived from stream sediment.

Data for 110 stream-sediment samples and 3 concentrate samples included in this report are from samples collected and analyzed during 1967 and 1968 for the Emigrant Basin Primitive Area study (Tooker and others, 1970). The rest of the samples were collected and analyzed during 1978 and 1979, specifically for the present report. A combined tabulation of all these analyses is published as U.S. Geological Survey Open-File Report 80-881 (Chaffee and others, 1980). This same tabulation is also available on computer tape from the National Technical Information Service (McDanal and others, 1981).

GENERAL GEOLOGY

The Walker Lake quadrangle includes parts of two major physiographic provinces: the Sierra Nevada-Cascade Mountains and the Basin and Range provinces. These two provinces have contrasting geological frameworks that reflect their different geologic histories. Because the geology of the Walker Lake quadrangle is complex, only a brief generalized summary is given here.

Sierra Nevada-Cascade Mountains province

Most of the western one-third of the quadrangle is in the Sierra Nevada. The Sierra Nevada includes the major Sierra Nevada batholith, which is composed of plutons ranging from Permian(?) to Late Cretaceous in age (Keith and Seitz, 1981). These plutons range from alaskite to gabbro in composition, with the majority of the rocks being in the quartz monzonite to granodiorite range. This plutonic complex has intruded and metamorphosed a sequence of Paleozoic and Mesozoic rocks that comprise both clastic- and carbonate-rich sedimentary rocks as well as volcanic (and plutonic?) rocks. Overlying these older units locally are Tertiary volcanic rocks consisting of flows, breccias, and lahars, and intrusive dikes, sills, and necks. Most of these Tertiary volcanic rocks are andesitic in composition; however, rocks of rhyolitic composition are present locally. Glacial and landslide deposits are present locally in many of the valleys in the Sierra Nevada.

Basin and Range province

Most of the eastern two-thirds of the quadrangle is in the Basin and Range physiographic province. Much of this part of the quadrangle contains thick sequences of extensively block-faulted Paleozoic and Mesozoic sedimentary rocks of widely varying compositions. Mesozoic plutons, which range in composition from alaskite to gabbro but are predominantly in the granite to granodiorite range, have intruded and locally metamorphosed the overlying sedimentary rocks. A long history of Tertiary volcanism is recorded in the eastern part of the quadrangle; thick sequences of flows, breccias, and tuffs, ranging in composition from rhyolite to basalt, are found throughout much of the area. Tertiary clastic sedimentary rocks were deposited in some areas. Tertiary and Quaternary volcanic flows, breccias, and shallow intrusive rocks, ranging in composition from rhyolite to basalt, are also present locally. Alluvial, lacustrine, and eolian sedimentary deposits are present in most of the valleys in this part of the quadrangle.

Geologic base for the geochemical maps

A simplified geologic base map of the Walker Lake quadrangle has been used with each of the accompanying geochemical maps. A more detailed geologic map of the quadrangle is available as a separate chapter in this Walker Lake folio (Stewart and others, 1982). For purposes of discussion in this report, some of the geologic units shown on the geologic map of Stewart and others (1982) have been consolidated into three major units.

Paleozoic and Mesozoic rocks--All of the pre-Cretaceous (Paleozoic and Mesozoic) igneous and sedimentary rock units (units Pz and Mz on map) have been consolidated into this one unit. Many but not all of these rocks have been metamorphosed.

Mesozoic intrusive rocks--Plutons ranging in composition from alaskite to gabbro compose this unit (unit Mzgr on map).

Tertiary volcanic rocks--This unit is composed predominantly of flow rocks of andesitic composition, but it also includes necks and flows ranging in composition from rhyolite to basalt as well as felsic to intermediate tuffs (includes units Tt and Ta on map).

ECONOMIC GEOLOGY

The Walker Lake quadrangle contains many mines and prospects. As a result of the complex geologic history of the area, many different mineral-deposit environments exist within the quadrangle. On the basis of geological and geochemical studies conducted for the reports in this folio, as well as on the recorded mining in the region, the commodities thought to have the greatest resource potential within the Walker Lake quadrangle are copper, lead, zinc, gold, silver, molybdenum, tungsten, and uranium. Thus, this geochemical study emphasizes those elements and element suites that may prove useful in locating areas containing (1) base and precious metals[1] and tungsten in vein or contact-metasomatic deposits, (2) copper and (or) molybdenum porphyry-type deposits, and (3) disseminated gold deposits. Studies related to uranium deposits are described elsewhere (Durham and Felmlee, 1982; Fay and Jones, 1980).

NATURE AND SCOPE OF THE GEOCHEMICAL SAMPLING

The geochemical sampling program for the Walker Lake quadrangle was based on collecting as many as three different types of samples--rock, minus-60-mesh stream sediment, and nonmagnetic heavy-mineral concentrate derived from stream sediment--at preselected locations throughout the quadrangle. Most of the samples of alluvial material were collected from first-order (unbranched) and second-order (below the junction of two first-order) stream channels as shown on 1:62,500-scale topographic maps.

The chemical analyses of the samples of stream sediment and concentrate provide information that may be used by the evaluator to separate the background concentrations of the elements discussed in this chapter of the folio from their anomalous concentrations. Anomalous concentrations may indicate the presence of as yet unknown mineral deposits that may be either exposed or buried. Plots of the analyses can be used to delineate those areas where samples have been found to contain anomalous concentrations of one or more elements commonly associated with ore processes.

Many anomalies shown on the accompanying maps are related to known mining activity. Some known mineral deposits are not reflected by anomalies, however, primarily because they are not close to sampled stream channels but also because not all samples collected were truly representative of the material being eroded upstream from the sample site. Because the sampling was designed and executed on a reconnaissance scale, some relatively small but exposed areas of anomalous rock may not have been detected despite proximity to sampled stream channels. Mineral deposits not exposed at the surface may not be easily detected even if part of the deposit system, such as an alteration aureole, is exposed. Additional detailed geochemical surveys would be necessary to identify and delineate specific mineralized areas.

Deposits of both placer minerals and saline, playa-associated minerals have been mined in the past in many of the alluvium-filled valleys and basins scattered throughout the Walker Lake quadrangle. The sampling program for the present study was designed primarily to evaluate areas of outcrop; thus, mineral deposits that may be present in alluvial-filled valleys and basins are excluded from consideration in this geochemical report.

DESCRIPTION OF THE SAMPLE MEDIA

Sediment was collected from active stream channels and processed to produce the minus-60-mesh stream-sediment and the nonmagnetic heavy-mineral-concentrate samples. Unlike rock samples, which represent a restricted, essentially point source, the sediment collected at a given site is considered to represent a composite of outcrop material eroded from the entire drainage basin upstream from the collection site.

The stream-sediment samples provide information about the elements in all of the minerals present in the eroded rock materials. In contrast, the concentrate samples provide information about the elements in only a limited number of minerals. The concentrating process removes most of the quartz, feldspar, clay minerals, and highly magnetic minerals. This selective concentration of minerals commonly related to mineral deposits permits determination of some elements that are not commonly detected in stream-sediment samples by emission spectroscopy. The concentrate chemistry may also be specific for certain minerals. For example, the concentration of barium in a stream-sediment sample represents the sum of barium contained in barite plus barium contained in potassium feldspars and possibly other minerals. Because of the processing procedures used, the barium in a concentrate sample represents predominantly the single mineral barite.

SAMPLE PREPARATION AND ANALYSIS

Sample preparation

The stream-sediment samples were composited from active alluvium collected from several locations within a 50-ft (15-m) radius of the localities shown on the accompanying maps. Each resulting sample was air-dried and then sieved. The material passing a screen with 0.25-mm openings (a 60-mesh screen) was saved and pulverized.

The concentrate samples were processed from the same composited active alluvium material collected for the minus-60-mesh stream-sediment samples. The material was wet-panned until most of the quartz, feldspar, organic material, and clay-sized material was removed. The samples were air-dried, and the highly magnetic material was removed using a magnet. Any light material remaining in the concentrate was then separated by allowing the heavier fraction of the sample to settle through bromoform (specific gravity 2.86). The resulting heavy-mineral fraction was then separated into a magnetic and a relatively nonmagnetic fraction using a Frantz Isodynamic Separator[2] set at 0.6 amperes, with 15° forward and 15° side settings. The resulting nonmagnetic fraction was pulverized in an agate mortar.

Sample analysis

Both stream-sediment and nonmagnetic heavy-mineral-concentrate samples were analyzed for 31 elements (Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, and Zr) using a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). Because of the limited amount of sample material, the concentrate samples were only analyzed spectrographically. The stream-sediment samples were also analyzed for arsenic by colorimetry (Ward and others, 1963), for zinc, antimony, and gold by atomic-absorption spectrometry (Ward and others, 1969; Welsch and Chao, 1975; Meier, 1980), and for cadmium and bismuth from a single solution by atomic-absorption spectrometry (Viets, 1978). Analyses for both sample types were performed partly in the field in a mobile chemistry laboratory and partly in U.S. Geological Survey laboratories near Golden, Colo.

The spectrographic analytical values are reported as the approximate geometric midpoints (0.15, 0.2, 0.3, 0.5, 0.7, and 1.0, or appropriate powers of ten of these values) of concentration ranges whose respective boundaries are 0.12, 0.18, 0.26, 0.38, 0.56, 0.83, and 1.2 (or appropriate powers of ten of these values). In general, the precision of the spectrographic method is plus or minus one reporting value of the value given by the analyst approximately 83 percent of the time and plus or minus two reporting values of the value given by the analyst 96 percent of the time (Motooka and Grimes, 1976). A reference standard sample was analyzed with each batch of field samples to monitor the quality of the analyses.

For the six elements analyzed by colorimetry or atomic-absorption spectrometry, the reporting values vary with the element and with the concentration level for any given element. Precision for these analytical methods is commonly reported as a percent relative standard deviation and is based on replicate analyses of samples selected to provide information at different concentration levels. In general, the precision for each method tends to be lowest for those samples containing a given element at or near its lower limit of determination. For the six elements discussed in the geochemical chapters in this folio, the reported ranges of percent relative standard deviation (RSD) are as follow:

Element	Range of percent RSD	Source of data
As	0.0-48.9	Unpublished analyses by R. H. Hill, 1981
Zn	3.4-30.2	Ward and others, 1969, p. 21
Sb	3.7-10.7	Welsch and Chao, 1975
Au	0.0-22.8	Meier, 1980
Cd	3.3-18.8	Viets, 1978
Bi	1.4-4.0	Viets, 1978

As an example to use in interpreting these ranges, one might consider antimony, whose range is shown as 3.7-10.7 percent RSD. This range indicates that a reported antimony value should be within ± 10.7 percent (usually much less) of the mean value for that sample.

EVALUATION OF THE CHEMICAL ANALYSES

Of the 37 elements determined in the stream-sediment samples (table 1), 12 elements (Ag, As, Au, Bi, Cd, Cu, Mo, Pb, Sb, Sn, W, and Zn) were selected as those most likely to be associated with hydrothermal alteration and (or) mineralization of the types known or thought to exist in the Walker Lake quadrangle. Of the 31 elements determined in the concentrate samples, 17 elements (Ag, As, Au, B, Ba, Bi, Cd, Co, Cu, Fe, Mo, Pb, Sb, Sn, Sr, W, and Zn) were selected as possibly having the same associations. The chemical analyses for these individual selected elements have been plotted on maps in other chapters of this folio (Chaffee and others, 1988a, b, c, d). This chapter of the folio consists of maps based on an R-mode factor analysis program that is available in the U.S. Geological Survey STATPAC library (VanTrump and Miesch, 1977).

DISCUSSION OF R-MODE FACTOR ANALYSIS

Factor analysis is a mathematical technique that is widely used to identify common groups, or factors, of the variables in a data set, based on the variation in correlation coefficients of the variables. The technique is particularly suited to evaluations of large data sets, such as those created for the geochemical study of the Walker Lake quadrangle. R-mode factor analysis, as used for this report, objectively groups chemical elements that vary sympathetically in samples into a set of factors, containing one or more of the original elements. Ideally, R-mode factor analysis can be used subjectively by the interpreter to identify factors representing groups of elements that may have a common association that can be related to known or inferred geologic conditions in the study area. Factors representing felsic rock-forming elements, precious-metal-associated elements, alteration-aureole-associated elements, and so on, may be present. Other factors in the same factor model may have no obvious relationship to geologic conditions and can be ignored.

In factor analysis individual elements are often components of more than one factor. The relative degree with which a given element correlates with a given factor is called its factor loading value. Within each factor, the relative degree with which each sample correlates with the factor is called its factor score. The factor scores created by the R-mode program used for this study range in value from -1.0 to +1.0; the sample having the +1.0 value (the end member) is considered the most significant for a given factor in terms of identifying mineralized localities. Thus, the closer the factor score for a given sample is to +1.0, the more favorable is the locality represented by that sample for being similar chemically to the sample with the +1.0 factor score.

For the geochemical study of the Walker Lake quadrangle, the principal components extracted in the R-mode factor analysis were rotated according to an oblique solution available in the U.S. Geological Survey STATPAC library (VanTrump and Miesch, 1977). This solution was selected because it tends to emphasize the extreme values (end members) in a data set; these extreme values tend to be related to mineralization.

For further details of applications of R-mode factor analysis to the evaluation of geologic problems, the reader may wish to consult reference books, such as Davis (1973).

APPLICATION OF R-MODE FACTOR ANALYSIS TO THE CHEMICAL ANALYSES

For the geochemical study of the Walker Lake quadrangle, elements having a high percentage (generally above 90 percent) of qualified values (values listed by the analyst as "G" (greater than) or "L" (less than) some limiting value or as "N" (not detected" at some lower limit of determination)) were deleted from the data set used in the factor-analysis program. For this report 10 elements (As, Au, Bi, Cd, Nb, Sb, Sn, Th, W, and Zn) were deleted from the data set because of an excessively high percentage of qualified values in spectrographic analyses of stream-sediment samples. Six elements (As, Au, Bi, Cd, Sb, and Zn) were deleted because of an excessively high percentage of qualified values in spectrographic analyses of concentrate samples. Because gold was determined by atomic-absorption spectroscopy in only about 10 percent of the stream-sediment samples, it, too, was deleted from the stream-sediment data set.

For those remaining elements (tables 2 and 3) logical unqualified values were substituted for the qualified values. Where such substituting was done, the values assigned for "greater than" or "less than" a limiting value are one standard reporting value above or below the limiting value, respectively. For those samples reported by the analyst as "not detected" at some lower limit of determination, the substituted value was three standard reporting values below the lower limit of determination. The analytical values for most of the ore-related elements studied for this report were found to most closely approximate lognormal distributions. Thus, after substitutions were made, the analyses were converted to logarithms.

For this report the 8-factor models for both the stream-sediment and concentrate data sets were selected as the ones that seemed to best fit known or expected types of mineralization in the Walker Lake quadrangle. The 8-factor model accounts for 74 percent of the overall data variability for both the stream-sediment samples and the concentrate samples. On the basis of the plan to concentrate on locating specific types of mineral deposits, one factor was chosen from the 8-factor model of the stream sediment and three factors were chosen from the 8-factor model of the concentrate samples for plotting for this chapter of the folio. The complete lists of values for the factor loadings for the two selected models are given in tables 4 and 5.

For the map plots, the samples were arranged by their factor scores in descending order from +1.0 to -1.0 and were then assigned to class intervals that were arbitrarily divided at approximately the 85th, 90th, 95th, and 98th percentiles. Map symbols were then assigned to each class and plots were made using the symbols shown on the respective maps in this chapter of the folio.

The Walker Lake quadrangle contains a large variety of known or suspected mineral deposit types. Many ore-related elements are probably associated with more than one type of mineral deposit; in addition, many of these same elements, especially in the stream-sediment samples, may be enriched in common rock-forming minerals such as feldspars, micas, and amphiboles. Because of these associations, the results of the R-mode factor analysis are often difficult to interpret in terms of deposit types.

DISCUSSION OF THE MAPS

Factor map for minus-60-mesh stream sediment

Only factor 7 of the 8-factor model for the stream-sediment samples is considered to be strongly related to mineralization (table 4). Map A shows the distributions of anomalies based on factor 7. The loadings on factor 7 include, in order of importance from highest to lowest, the elements antimony, silver, arsenic, lead, zinc, cadmium, boron, and copper (table 4). This factor is interpreted to represent a dominant precious-metal and a subdominant base-metal assemblage; thus, this map should be a useful guide to silver, gold, and base-metal deposits. Because the elements listed above are often present in aureoles around large zoned deposits, the anomalous localities shown on this map may also result from the presence of large unexposed porphyry deposits or other types of deposits. The sample with the factor score of +1.0 for factor 7 (the most significant sample for the elements listed) is from the Candelaria district (area J on map A), a predominantly precious-metal district.

The upper 5 percent of the samples in the stream-sediment data set have been arbitrarily selected as anomalous. The most significant sites and areas, as identified by the R-mode factor analysis program, are (A) the Monitor district and the area extending to the northeast, (B) the Buckskin area west of Yerington, (C) the east-central part of the Wellington Hills, (D) the Pine Grove district in the Pine Grove Hills, (E) the Silverado district in the Sweetwater Mountains, (F) the Masonic district, (G) the Bodie and Aurora districts, (H) the Lundy Canyon area west of Mono Lake, (I) the south-central Excelsior Mountains, (J) the Candelaria district in the Candelaria Hills, (K) the contaminated area downstream from the old Candelaria mill site at Belleville, (L) the area comprising the western part of the Pilot Mountains and the northeastern part of the Excelsior Mountains, (M) the area comprising the northeastern Garfield Hills and the southern end of the Gabbs Valley Range, and (N) the area where the Gabbs-Luning highway crosses the Gabbs Valley Range.

Most of the areas listed above are associated with the Paleozoic and Mesozoic rocks. The one obvious exception is the Monitor district (area A), which is entirely associated with Tertiary volcanic rocks.

Factor maps for nonmagnetic heavy-mineral concentrate

Factors 4, 6, and 7 of the 8-factor model for the concentrate samples are considered to be related to mineralization (table 5). Maps B and C show the distributions of anomalies based on factors 4 and 6. The loadings on factor 4 include, in order of importance from highest to lowest, the elements silver, lead, molybdenum, copper, tungsten, and tin (table 5). This factor is interpreted to represent an element suite that should be a useful guide to porphyry molybdenum deposits as well as to contact-metasomatic deposits of tungsten and base and precious metals. The sample with the factor score of +1.0 for this factor is from the Silverado district (area C on map B), a precious-metal district that may also contain molybdenum deposits. The upper 5 percent of the samples in the concentrate data set have been arbitrarily selected as anomalous. The most significant sites and areas, as identified by the R-mode factor analysis program, are (A) the southern end of the Pine Nut Mountains, (B) the Pine Grove district in the Pine Grove Hills, (C) the Silverado district in the Sweetwater Mountains, (D) the Bodie and Aurora districts in the Bodie Hills, (E) the area between Virginia Lakes, Lundy Canyon, and Conway Summit northwest of Mono Lake, (F) the Corey Peak area in the central Wassuk Mountains, (G) the Buller Mountain area in the southern Wassuk Mountains, (I) the Eastside mine area south of Teels Marsh, (J) the Candelaria district in the Candelaria Hills, (K) the south-central Excelsior Mountains north of Marietta, (L) the Camp Douglas-Thunder Mountain area at the east end of the Excelsior Mountains, and (M) the area on the north side of Mable Mountain in the Garfield Hills. The anomaly at site (H) is probably related to contamination associated with scrap metals placed in that area by personnel of the Hawthorne Army Ammunition Depot.

Most of the significant sites described above are associated either with the Paleozoic and Mesozoic rocks or with the Tertiary volcanic rocks, especially where either of these major assemblages is in the vicinity of Mesozoic intrusive rocks. Porphyry-type molybdenum deposits normally are contained within one or more intrusive rock units; however, here any porphyry-type molybdenum deposits in the areas associated with the sites described above are not likely to be exposed. Any contact-metasomatic deposits, on the other hand, probably are exposed.

Map C shows the distributions of anomalies based on factor 6 of the 8-factor model. The loadings on this factor include, in order of importance from highest to lowest, the elements copper, lead, cobalt, silver, iron, strontium, and barium (table 5). This factor contains the elements iron, cobalt, barium, and strontium that commonly occur in the Walker Lake quadrangle in areas of hydrothermal alteration accompanied by strong pyritization, particularly in Tertiary volcanic rocks. The copper, lead, and silver contribution to the factor probably is associated with base- and precious-metal mineralization related to vein deposits or possibly with concealed porphyry copper-type mineralization. The sample with the factor score of +1.0 for factor 6 is from the Monitor district (area A on map C), a precious-metal district that may also contain base metals.

The upper 10 percent of the samples in the concentrate data set have been arbitrarily selected as anomalous. The most significant sites and areas, as identified by the R-mode factor analysis program, are (A) the Monitor-Silver Creek area and the zone extending northeast from there to the southern Pine Nut Mountains; (B) the north end of the Wellington Hills; (C) the Relief Peak-Leavitt Peak area in the Sierra Nevada, (D) the area between Eagle Peak and Twin Lakes southwest of Bridgeport Valley; (E) the area between Lundy Canyon and Conway Summit, northwest of Mono Lake; (F) the south-central Excelsior Mountains north of Marietta; (G) the southern Miller Mountain area; (H) the Candelaria district in the Candelaria Hills; (I) a large area including the eastern Garfield Hills, the southern Gabbs Valley Range, and the western Pilot Mountains; (J) the north end of the Gabbs Valley Range; and (K) the Cottonwood Creek area in the central Wassuk Mountains. Most of the significant sites described above are associated either with the Paleozoic and Mesozoic rocks or with the Tertiary volcanic rocks.

Map D shows the distribution of anomalies based on factor 7 of the 8-factor model. The loadings on this factor include, in order of importance from highest to lowest, the elements tungsten, beryllium, manganese, boron, calcium, iron, and molybdenum (table 5). This factor contains a suite of elements that most likely represents contact-metasomatic tungsten deposits but might also locate areas favorable for porphyry molybdenum deposits. The sample with the factor score of +1.0 for this factor is from the Twin Lakes area, southwest of Bridgeport in the Sierra Nevada (area B on map D), an area containing contact-metasomatic tungsten deposits and locally containing precious metals.

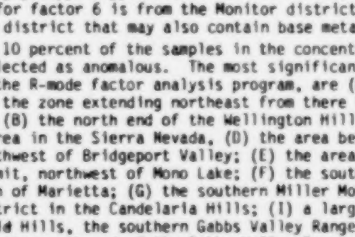
The upper 5 percent of all of the samples in the concentrate data set have been arbitrarily selected as anomalous. The most significant sites and areas, as identified by the R-mode factor analysis program, are (A) the southern Pine Nut Mountains, (B) the large area between the Little Walker River and Lundy Canyon in the Sierra Nevada, (C) the Red Wash Creek area east of the Masonic district, (D) the Cottonwood Creek area near Buller Mountain in the southern Wassuk Mountains, (E) an area south of Miller Mountain near the southeastern corner of the quadrangle, (F) the eastern part of the Garfield Hills, (G) an area northwest of Gabbs Valley near the northern edge of the quadrangle, and (H) the area along the east side of the northern Wassuk Mountains.

Most of the significant sites described above are located in either the Paleozoic and Mesozoic rocks or the Mesozoic intrusive rocks, and, generally, where these two rock assemblages are in close proximity. This geologic setting is readily permissible for the typical environment for contact-metasomatic tungsten deposits.

For all of the maps in this part of the folio there is no assurance that all of the anomalies identify known or unknown mineral deposits or that all of the deposits in the categories thought to be represented by each map have in fact been identified. It is recommended that all of the maps in the entire folio be consulted as a part of any decision-making process.

Note: The following correlation and description of map units are for the geologic base map shown in gray

CORRELATION OF MAP UNITS



REFERENCES

Chaffee, M.A., 1988a, Distributions of anomalies based on the use of SCORESUM plots for selected groupings of elements in samples of minus-60-mesh (0.25-mm) stream sediment, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-L, scale 1:250,000.

______1988b, Distributions of anomalies based on the use of SCORESUM plots for selected groupings of elements in samples of nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-M, scale 1:250,000.

Chaffee, M.A., Hill, R.H., Speckman, W.S., and Sutley, S.J., 1980, Preliminary data set containing geochemical analyses of samples of rock, stream sediment, and nonmagnetic heavy-mineral concentrate, Walker Lake 2° quadrangle, California and Nevada: U.S. Geological Survey Open-File Report 80-881, 235 p.

Chaffee, M.A., Hill, R.H., and Sutley, S.J., 1988a, Distributions of copper, lead, zinc, cadmium, and silver in samples of minus-60-mesh (0.25-mm) stream sediment and nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Miscellaneous Field Studies Map MF-1382-G, scale 1:250,000.

______1988b, Distributions of molybdenum, tin, boron, tungsten, and gold in samples of minus-60-mesh (0.25-mm) stream sediment and (or) nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-H, scale 1:250,000.

______1988c, Distributions of iron, cobalt, barium, strontium, arsenic, antimony, and bismuth in samples of minus-60-mesh (0.25-mm) stream sediment and (or) nonmagnetic heavy-mineral concentrate, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-I, scale 1:250,000.

______1988d, Distributions of 12 selected elements in samples of rock, Walker Lake 1° x 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-J, scale 1:250,000.

Davis, J.C., 1973, Statistics and data analysis in geology: New York, John Wiley and Sons, 550 p.

Durham, D.L., and Felmlee, J.K., 1982, National uranium resource evaluation, Walker Lake quadrangle, California and Nevada: U.S. Department of Energy, Grand Junction Office, Open-File Report PGJ/F-010(82).

Fay, W.M., and Jones, P.L., 1980, Hydrochemical and stream sediment reconnaissance, Walker Lake 1° x 2° NTMS Area, California and Nevada: U.S. Department of Energy Report DPST-79-146-13, 51 p., 10 plates, 6 microfiche.

Grimes, D.J., and Marranzino, A.P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

McDanal, S.K., Speckman, W.S., and Chaffee, M.A., 1981, Spectrographic and chemical analyses of rock, stream-sediment, and concentrate samples from the Walker Lake 2° quadrangle, California and Nevada: available as a magnetic tape from National Technical Information Service, Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Meier, A.L., 1980, Flameless atomic-absorption determination of gold in geological materials: Journal of Geochemical Exploration, v. 13, no. 1, p. 77-85.

Stewart, J.H., Carlson, J.E., and Johannesen, D.C., 1982, Geologic map of the Walker Lake 1° x 2° quadrangle, U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-A, scale 1:250,000.

Tooker, E.W., Morris, H.T., and Fillo, P.V., 1970, Mineral resources of the Emigrant Basin Primitive Area, California, with a section on Geophysical studies, by H. W. Oliver: U.S. Geological Survey Bulletin 1261-G, 70 p.

VanTrump, George, and Miesch, A.T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geosciences, v. 3, p. 479-488.

Viets, J.G., 1978, Determination of silver, bismuth, cadmium, copper, lead, and zinc in geologic materials by atomic absorption spectrometry with tricaprylylmethylammonium chloride: Analytical Chemistry, v. 50, no. 8, p. 1097-1101.

Ward, F.N., Lakin, H.W., Canney, F.C., and others, 1963, Analytical methods used in geochemical exploration by the U.S. Geological Survey: U.S. Geological Survey Bulletin 1152, 100 p.

Ward, F.N., Nakagawa, H.M., Harms, T.M., and VanSickle, G.H., 1969, Atomic-absorption methods of analysis useful in geochemical exploration: U.S. Geological Survey Bulletin 1289, 45 p.

Welsch, E.P., and Chao, T.T., 1975, Determination of trace amounts of antimony in geological materials by atomic absorption spectrometry: Analytical Chimica Acta, v. 76, p. 65-69.

DESCRIPTION OF MAP UNITS

Qa	ALLUVIAL, LACUSTRINE, EOLIAN, LANDSLIDE, AND GLACIAL DEPOSITS, UNDIVIDED (QUATERNARY)--As mapped locally includes uppermost Tertiary gravel
QTb	BASALT (QUATERNARY AND TERTIARY)--Ranges in age from about 9 m.y. to less than 1 m.y.
QTa	ANDESITE TO RHYOLITE (QUATERNARY AND TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks. Ranges in age from about 5 m.y. to less than 1 m.y.
Ts	SEDIMENTARY ROCKS (TERTIARY)--Tuffaceous sandstone, siltstone, and conglomerate to gravel. Minor tuff and volcanic breccia. Ranges in age from about 12 m.y. to 2 m.y.
Ta	ANDESITE TO RHYOLITE (TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks, latitic to rhyolitic ash-flow tuffs, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from about 22 m.y. to 5 m.y.
Tt	TUFF (TERTIARY)--Welded and nonwelded rhyolitic ash-flow tuff. Minor rhyolite flows and shallow intrusive rocks, andesite flows, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from 30 m.y. to 22 m.y.
Mzgr	GRANITIC ROCKS (MESOZOIC)--Granite to granodiorite. Minor dioritic, gabbroic, and felsic intrusive rocks
Mz	VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED (MESOZOIC)--Andesitic to rhyolitic lava flows, breccia, tuff, volcanic sandstone, and conglomerate; shallow marine siltstone, sandstone, conglomerate, and limestone; continental sandstone and conglomerate. Metamorphosed near granitic rocks
Pz	SEDIMENTARY AND VOLCANIC ROCKS, UNDIVIDED (PALEOZOIC)--Deep-water marine chert, phyllite, shale, carbonate rocks, volcanogenic turbidite, sandstone, and conglomerate (Ordovician, Devonian, Pennsylvanian, and Permian); shallow-water siltstone, sandstone, conglomerate, and carbonate (Cambrian, Mississippian, and Permian; as mapped includes upper Proterozoic rocks at one locality); and andesitic breccia and lava (Permian). Metamorphosed near granitic rocks

———	GEOLOGIC CONTACT
━━━	HIGH-ANGLE FAULT--Dotted where concealed
▲▲▲	THRUST OR LOW-ANGLE FAULT

---

[1] The term base metals in this report includes some or all of the elements antimony, arsenic, bismuth, cadmium, copper, lead, and zinc. The precious metals are silver and gold.

[2] The use of trade names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

La	20	--	50	2,000
Mg	0.02	--	0.05	--
Mn	10	5,000	20	--
Mo	5	--	10	--
Nb	20	--	50	--
Ni	5	--	10	--
Pb	10	--	20	--
Sb	100	--	200	--
Sc	5	--	10	--
Sn	10	--	20	--
Sr	100	--	200	10,000
Th	200	--	500	5,000
Ti	0.002	1.0	0.005	2.0
V	10	--	20	--
W	50	--	100	--
Y	10	--	20	--
Zn	200	--	500	--
Zr	10	1,000	20	2,000
As-cm	10	400	--	--
Au-aa	0.005	--	--	--
Bi-aa	0.5	--	--	--
Cd-aa	0.05	--	--	--
Sb-aa	1.0	--	--	--
Zn-aa	5		--	--

Table 2.--Summary of the number of qualified and unqualified analyses for selected elements in 1,116 samples of minus-60-mesh stream sediment

["N" indicates not detected at the lower limit of determination shown in table 1. "L" indicates detected but in a concentration below the lower limit of determination shown in table 1. "G" indicates detected but in a concentration greater than the upper limit of determination shown in table 1. "B" indicates samples not analyzed. "aa" following the element symbol indicates atomic absorption analysis; "cm" indicates colorimetric analysis; no suffix indicates spectrographic analysis]

Element	Number of unqualified samples	Qualified samples			
		Number of N	Number of L	Number of G	Number of B
Ag	90	970	56	0	0
B	1,011	50	47	0	8
Ba	1,116	0	0	0	0
Be	1,015	8	93	0	0
Ca	1,116	0	0	0	0
Co	1,055	28	33	0	0
Cr	1,020	8	88	0	0
Cu	1,071	4	41	0	0
Fe	1,115	0	0	1	0
La	1,055	32	29	0	0
Mg	1,116	0	0	0	0
Mn	1,115	0	0	1	0
Mo	306	697	113	0	0
Ni	955	53	108	0	0
Pb	1,103	3	10	0	0
Sc	1,065	9	34	0	8
Sr	1,114	0	2	0	0
Ti	1,113	0	0	3	0
V	1,116	0	0	0	0
Y	1,053	8	55	0	0
Zr	1,110	0	0	6	0
As-cm	111	749	145	1	110
Bi-aa	429	247	330	0	110
Cd-aa	805	60	141	0	110
Sb-aa	947	4	55	0	110
Zn-aa	1,068	0	0	0	48

Table 3.--Summary of the number of qualified and unqualified analyses for selected elements in 1,006 samples of heavy-mineral concentrate

["N" indicates not detected at the lower limit of determination shown in table 1. "L" indicates detected but in a concentration below the lower limit of determination shown in table 1. "G" indicates detected but in a concentration greater than the upper limit of determination shown in table 1. "B" indicates samples not analyzed]

Element	Number of unqualified samples	Qualified samples			
		Number of N	Number of L	Number of G	Number of B
Ag	88	911	6	0	0
B	697	182	123	2	1
Ba	891	4	21	89	0
Be	272	394	339	0	0
Ca	1,005	0	0	0	0
Co	773	74	158	0	0
Cr	948	9	48	0	0
Cu	637	107	261	0	0
Fe	1,002	0	2	1	0
La	983	1	12	9	0
Mg	999	0	6	0	0
Mn	1,005	0	0	0	0
Mo	521	325	159	0	0
Nb	718	82	205	0	0
Ni	497	238	270	0	0
Pb	843	92	70	0	0
Sc	996	0	8		1
Sn	690	235	80	0	0
Sr	826	123	54	2	0
Th	502	201	232	67	3
Ti	497	0	0	508	0
V	1,004	0	1	0	0
W	194	704	107	0	0
Y	1,003	0	2	0	0
Zr	456	0	0	549	0

Table 4.--Values for factor loadings for the 8-factor model using oblique rotation for samples of minus-60-mesh stream sediment

["aa" following the element symbol indicates atomic absorption analysis; "cm" indicates colorimetric analysis; no suffix indicates spectrographic analysis]

Element	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	FACTOR 7	Factor 8
Ag	0.32	0.08	-1.65	3.03	1.45	0.17	8.37	0.92
B	-2.24	-2.60	-0.52	1.13	0.36	0.33	3.66	0.09
Ba	-2.63	-0.57	0.67	-1.13	-2.15	0.67	2.26	-1.57
Be	-1.18	-1.58	-1.08	-0.84	0.37	0.84	1.52	0.10
Ca	-2.62	-1.28	0.97	-3.00	-2.60	0.34	-1.22	-1.79
Co	-1.13	-2.48	1.90	1.21	-2.18	0.24	0.76	-0.48
Cr	-1.57	-2.95	1.51	0.82	-1.43	-0.93	1.77	-0.95
Cu	-0.80	-1.69	1.45	1.77	-1.56	1.12	3.24	-0.13
Fe	0.40	-2.15	-0.01	-0.06	-2.90	0.71	0.78	-0.75
La	0.21	-3.18	-0.30	-0.34	0.68	0.05	0.87	0.69
Mg	-2.49	-2.59	1.64	0.37	-2.41	0.12	-0.68	-0.54
Mn	-0.24	-3.62	-0.14	1.24	-0.46	0.39	1.86	1.16
Mo	-0.94	-0.71	-0.65	2.01	0.50	0.54	0.40	3.12
Ni	-2.25	-2.32	1.93	0.72	-1.32	-0.83	2.25	-1.00
Pb	-0.01	-2.46	0.33	1.19	1.78	-0.09	5.91	1.53
Sc	-1.33	-3.28	1.56	1.39	-2.00	-0.25	-0.73	0.38
Sr	-2.24	-0.74	2.68	-5.22	-2.98	-1.12	-0.14	-2.33
Ti	0.07	-3.00	0.54	-0.82	-2.94	-0.46	0.57	-0.19
V	-0.32	-3.44	0.06	0.36	-2.01	0.15	1.50	-0.23
Y	0.12	-3.53	-0.64	1.74	-0.07	0.53	0.24	1.30
Zr	-0.01	-2.22	-1.14	-0.37	-1.67	0.90	0.26	-0.57
As-cm	-0.33	-0.34	-1.03	2.07	0.61	0.51	7.98	0.71
Bi-aa	0.56	0.61	1.29	-0.07	0.23	2.85	-0.66	-0.24
Cd-aa	0.34	0.79	0.33	0.52	-1.81	1.09	5.16	1.50
Sb-aa	-0.73	0.64	-3.03	1.45	0.15	-0.08	8.95	-2.49
Zn-aa	0.99	-0.47	0.46	1.21	-2.49	0.67	5.70	1.41

Table 5.--Values for factor loadings for the 8-factor model using oblique rotation for samples of nonmagnetic heavy-mineral concentrate

[All analyses are by emission spectroscopy]

Element	Factor 1	Factor 2	Factor 3	FACTOR 4	Factor 5	FACTOR 6	FACTOR 7	Factor 8
Ag	-0.02	0.27	1.88	6.00	1.19	2.66	0.55	-0.56
B	-1.63	-0.71	1.72	1.01	-0.62	-0.49	1.67	-0.69
Ba	-1.33	0.49	2.40	1.21	-0.91	1.37	0.22	2.25
Be	0.35	-0.35	1.99	-0.85	0.11	0.45	2.22	-0.20
Ca	0.14	-0.12	0.64	-2.55	0.66	-2.11	1.35	-3.77
Co	1.62	1.76	0.81	1.43	-1.63	2.70	-0.49	0.73
Cr	-1.67	1.81	-0.78	-1.00	-0.95	-0.27	-0.63	-1.12
Cu	0.58	0.71	2.72	4.36	0.75	3.45	0.73	1.06
Fe	-0.69	0.88	1.95	1.16	-0.08	1.98	1.03	-0.19
La	1.28	-0.57	-0.58	0.36	-2.01	-1.83	0.63	-0.39
Mg	-1.98	1.35	0.44	-1.45	-0.43	-0.75	0.56	-1.73
Mn	0.47	-1.08	1.34	-0.56	-0.57	-0.23	1.76	-3.81
Mo	0.50	0.89	1.92	4.83	2.22	0.07	1.01	-0.61
Nb	1.25	-0.42	0.36	0.15	-1.66	-2.09	0.35	-0.65
Ni	-0.72	1.96	-0.36	0.07	-0.84	0.78	-0.67	-0.87
Pb	0.95	-0.74	2.56	4.84	-0.54	3.02	0.27	0.62
Sc	-1.02	1.09	-1.50	-0.33	-2.56	-0.62	-0.58	-1.04
Sn	0.20	0.14	-0.71	1.67	-0.88	-1.47	-1.14	-1.45
Sr	-0.68	0.04	1.02	-0.43	-0.98	1.79	0.25	2.65
Th	2.47	0.23	-1.00	-0.59	-1.24	-0.77	0.46	0.66
Ti	0.26	-0.17	0.64	-0.11	-2.40	-2.97	-0.34	0.06
V	-0.44	0.32	4.15	0.18	-0.82	-1.72	0.17	-1.54
W	-0.65	1.41	-1.19	2.86	2.39	-1.05	4.47	-0.62
Y	0.99	-0.38	-0.30	-0.15	-1.92	-2.58	0.09	-0.47
Zr	-1.42	0.36	1.07	-0.13	-2.79	-3.48	-0.38	0.75

MAPS SHOWING DISTRIBUTION OF ANOMALIES BASED ON THE USE OF R-MODE FACTOR ANALYSIS FOR SELECTED GROUPINGS OF ELEMENTS IN SAMPLES OF MINUS-60-MESH (0.25-MM) STREAM SEDIMENT AND NONMAGNETIC HEAVY-MINERAL CONCENTRATE, WALKER LAKE 1° X 2° QUADRANGLE, CALIFORNIA AND NEVADA

By

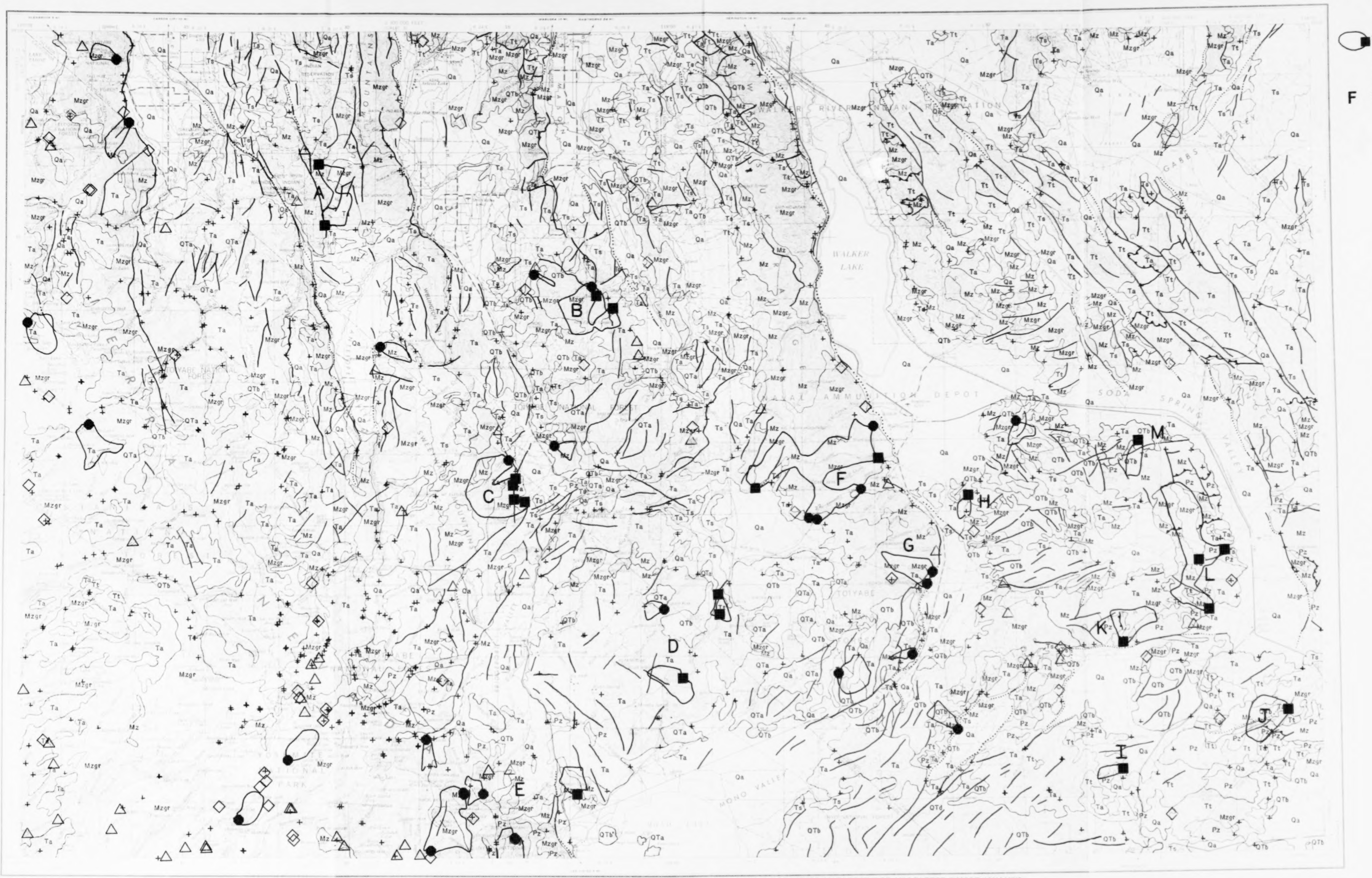
M.A. Chaffee

1988

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1988

For sale by U.S. Geological Survey Map Distribution, Box 25286, Federal Center, Denver, CO 80225

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

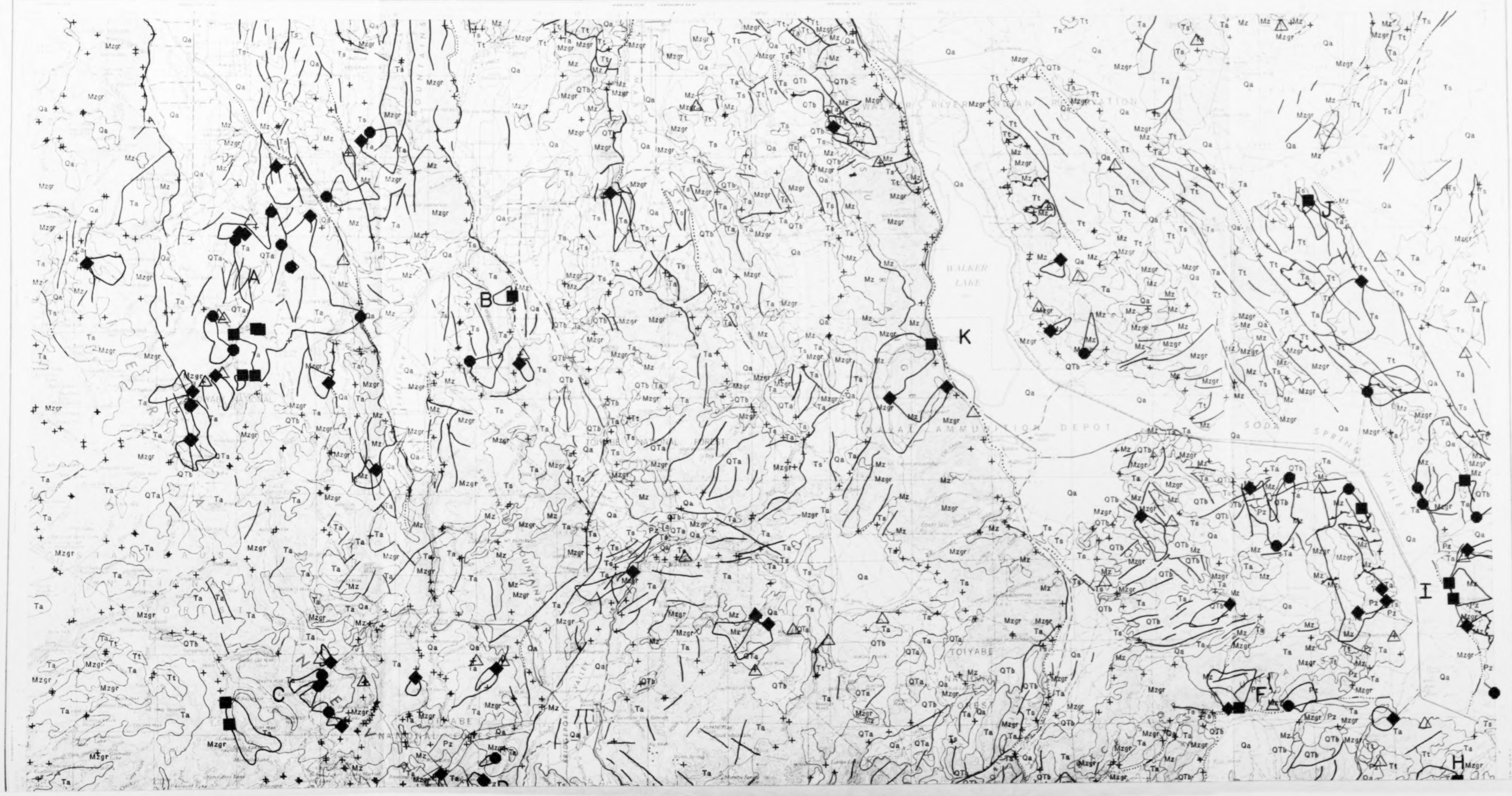

A
B
C
D
E
F
G
H
I
J
K
L
M
WALKER LAKE
AMMUNITION DEPOT
SODA SPRING VALLEY
TOIYABE
MONO VALLEY

EXPLANATION

SAMPLE LOCALITY AND BOUNDARY
Anomalous for concentrate s
loadings on factor 4. Loca
symbol. Square symbol indi
(98th percentile). Circle
next 5%; triangle, next 5%;
remaining 85%. Darkened s
significant sites

F SIGNIFICANT ANOMALOUS AREA OR
in text

MAP B. DISTRIBUTION OF SITES FOR NONMAGNETIC HEAVY-MINERAL-CONCENTRATE SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 4 OF AN 8-FACTOR R-MODE ANALYSIS


A
B
C
D
F
H
I
J
K
WALKER LAKE
AMMUNITION DEPOT
SODA SPRING VALLEY
TOIYABE

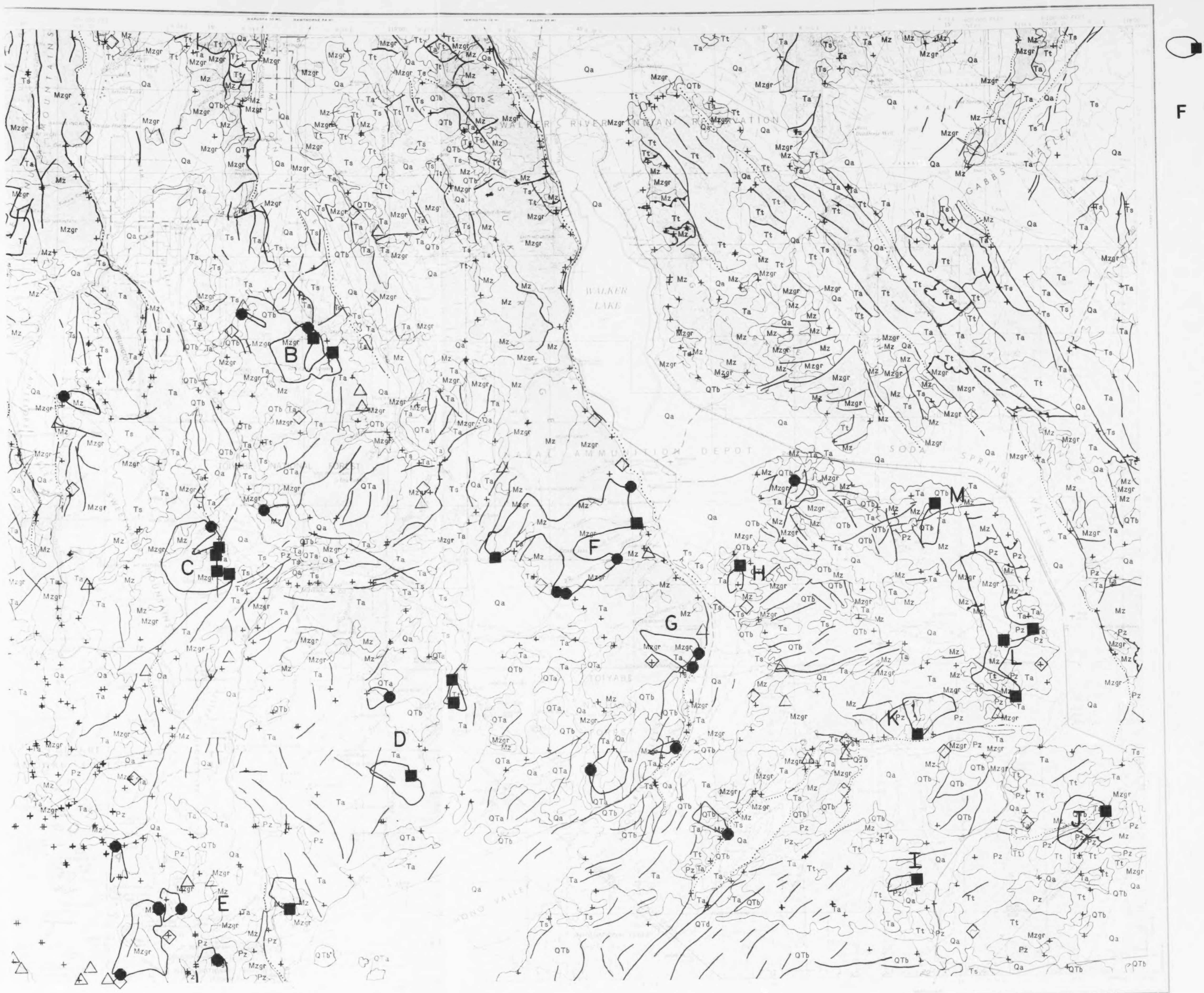
EXPLANATION

SAMPLE LOCALITY AND BOUNDARY
Anomalous for concentrate
loadings on factor 6.
symbol. Square symbol ind
(98th percentile). Circle
next 5%; triangle, next 5
remaining 85%. Darkened
significant sites

J SIGNIFICANT ANOMALOUS AREA
in text

best copy available

MISCELLANEOUS FIELD STUDIES
MAP MF-1382-K
SHEET 2 OF 2

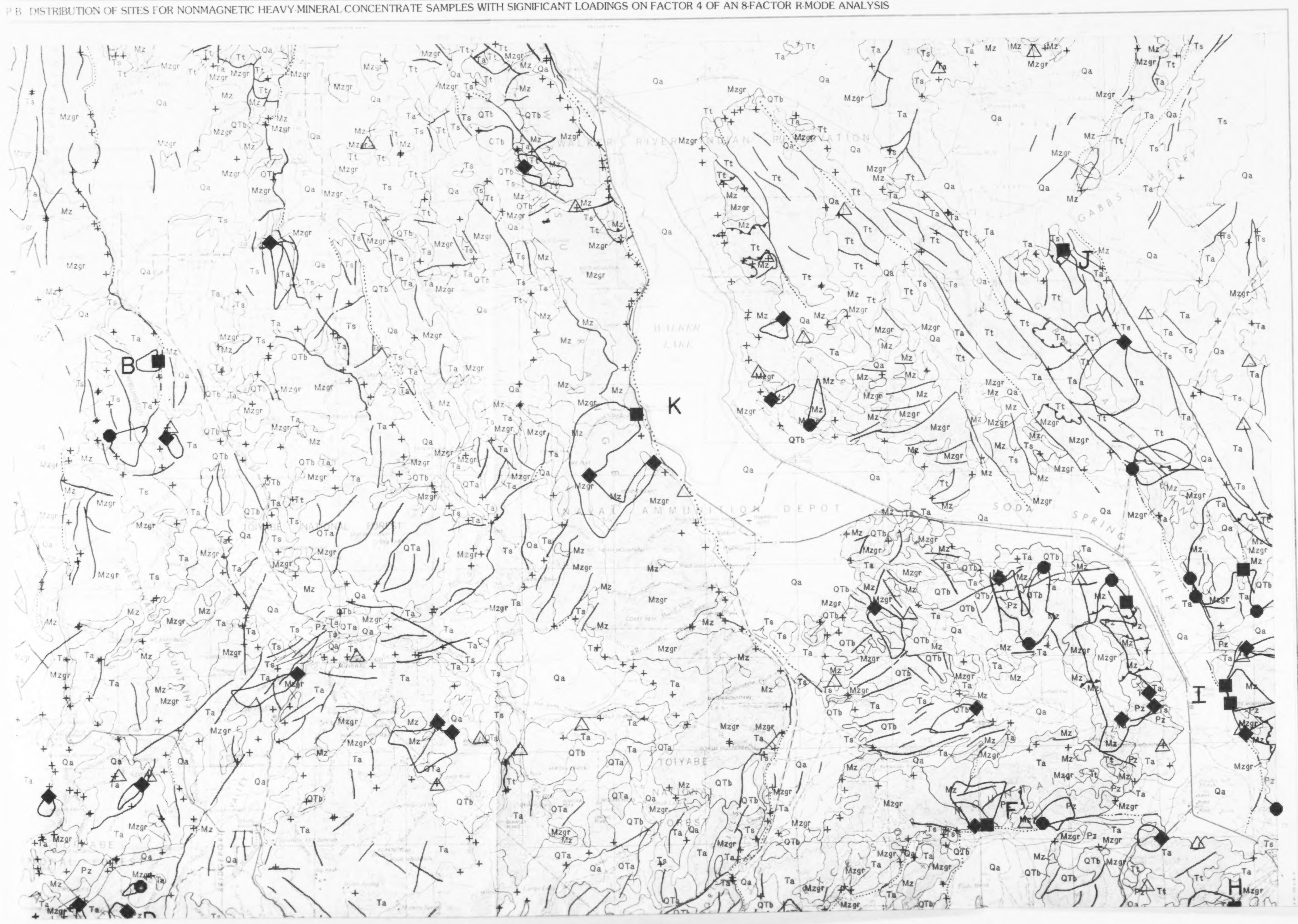


EXPLANATION

■ SAMPLE LOCALITY AND BOUNDARY OF ASSOCIATED DRAINAGE BASIN--Anomalous for concentrate samples with significant loadings on factor 4. Locality is at center of plotted symbol. Square symbol indicates upper 2% of the data (98th percentile). Circle symbol is next 3%; diamond, next 5%; triangle, next 5%; and plus symbol (+), remaining 85%. Darkened symbols identify the most significant sites

F SIGNIFICANT ANOMALOUS AREA OR SITE--Letter is keyed to list in text

P B. DISTRIBUTION OF SITES FOR NONMAGNETIC HEAVY-MINERAL-CONCENTRATE SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 4 OF AN 8-FACTOR R-MODE ANALYSIS



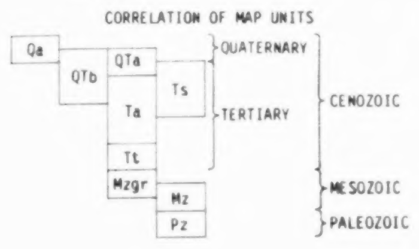
EXPLANATION

■ SAMPLE LOCALITY AND BOUNDARY OF ASSOCIATED DRAINAGE BASIN--Anomalous for concentrate samples with significant loadings on factor 6. Locality is at center of plotted symbol. Square symbol indicates upper 2% of the data (98th percentile). Circle symbol is next 3%; diamond, next 5%; triangle, next 5%; and plus symbol (+), remaining 85%. Darkened symbols identify the most significant sites

J SIGNIFICANT ANOMALOUS AREA OR SITE--Letter is keyed to list in text

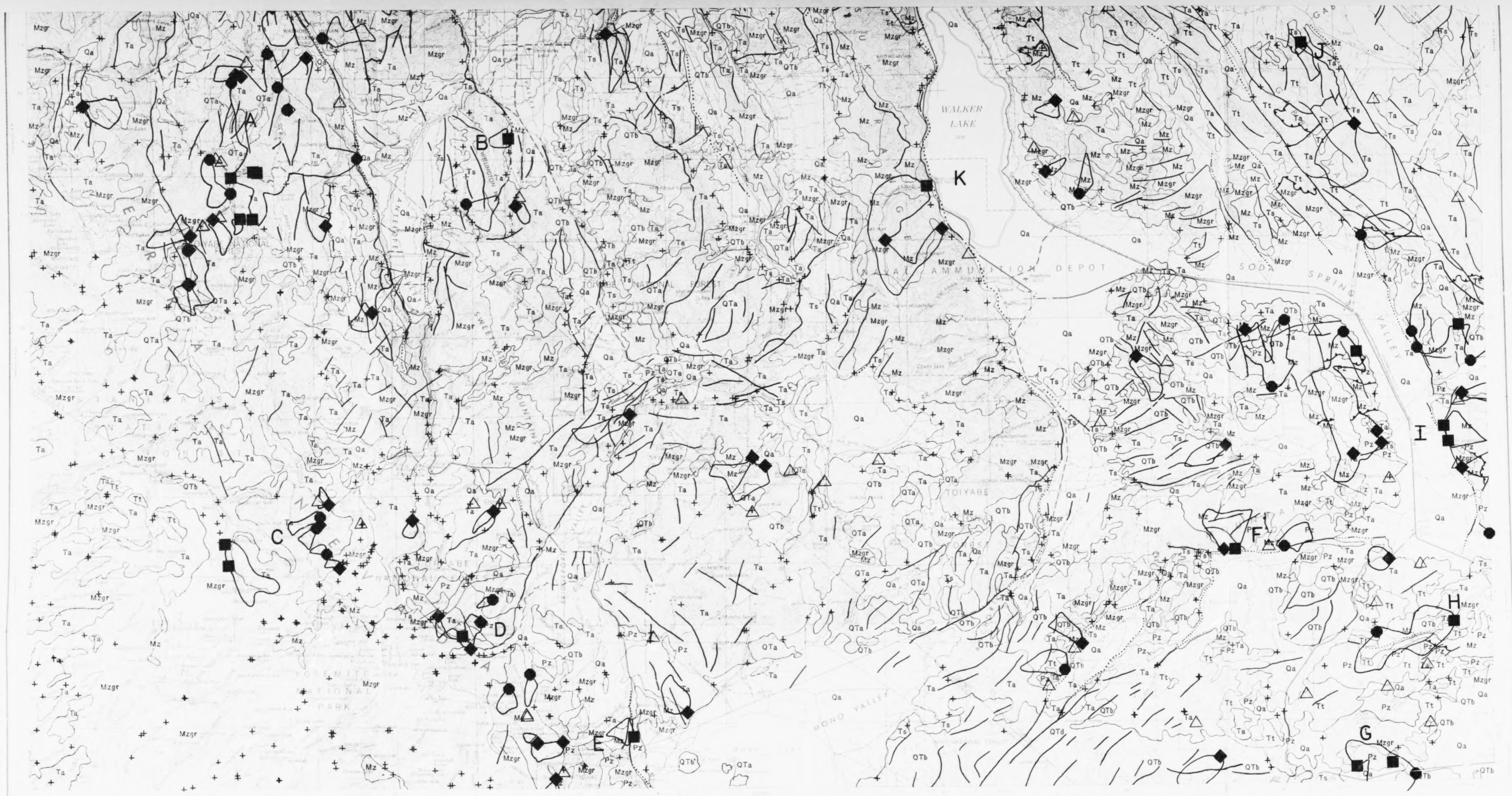
Note: The following correlation and description of map units are for the geologic base map shown in gray

CORRELATION OF MAP UNITS

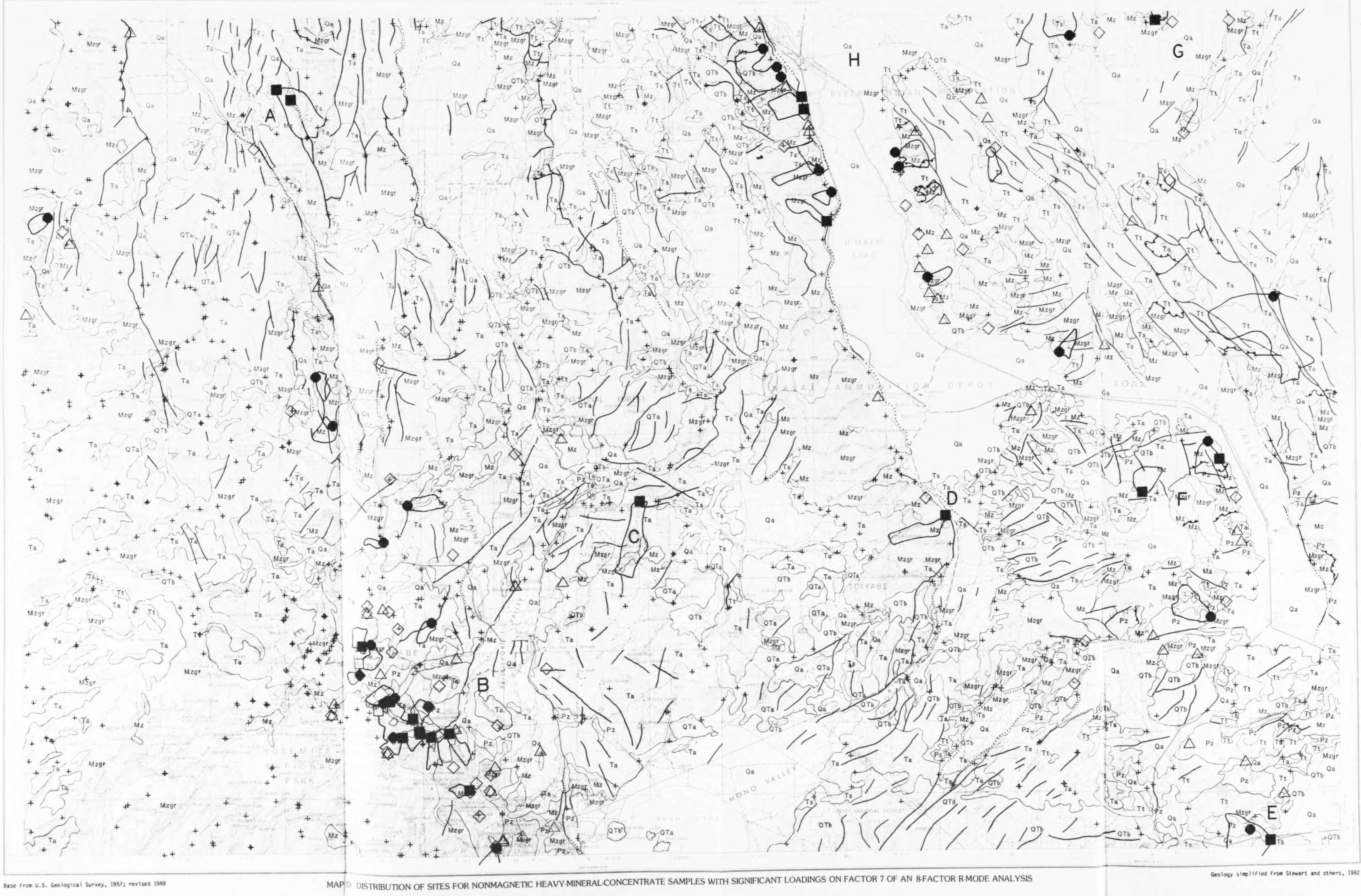


DESCRIPTION OF MAP UNITS

Qa	ALLUVIAL, LACUSTRINE, EOLIAN, LANDSLIDE, AND GLACIAL DEPOSITS, UNDIVIDED (QUATERNARY)--As mapped locally includes uppermost Tertiary gravel
QTb	BASALT (QUATERNARY AND TERTIARY)--Ranges in age from about 9 m.y. to less than 1 m.y.
QTa	ANDESITE TO RHYOLITE (QUATERNARY AND TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks. Ranges in age from about 5 m.y. to less than 1 m.y.
Ts	SEDIMENTARY ROCKS (TERTIARY)--Tuffaceous sandstone, siltstone, and conglomerate to gravel. Minor tuff and volcanic breccia. Ranges in age from about 12 m.y. to 2 m.y.
Ta	ANDESITE TO RHYOLITE (TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks, latitic to rhyolitic ash-flow tuffs, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from about 22 m.y. to 5 m.y.
Tt	TUFF (TERTIARY)--Welded and nonwelded rhyolitic ash-flow tuff. Minor rhyolite flows and shallow intrusive rocks, andesite flows, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from 30 m.y. to 22 m.y.
Mzgr	GRANITIC ROCKS (MESOZOIC)--Granite to granodiorite. Minor dioritic, gabbroic, and felsic intrusive rocks
Mz	VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED (MESOZOIC)--Andesitic to rhyolitic lava flows, breccia, tuff, volcanic sandstone, and conglomerate; shallow marine siltstone, sandstone, conglomerate, and limestone; continental sandstone and conglomerate. Metamorphosed near granitic rocks
Pz	SEDIMENTARY AND VOLCANIC ROCKS, UNDIVIDED (PALEOZOIC)--Deep-water marine chert, phyllite, shale, carbonate rocks, volcanogenic turbidite,


WALKER LAKE
AMMUNITION DEPOT
SODA SPRINGS VALLEY
TOIYABE
MONO VALLEY
A
B
C
D
E
F
G
H
I
J
K
Qa
QTb
QTa
Ta
Tt
Ts
Mz
Mzgr
Pz

MAP C. DISTRIBUTION OF SITES FOR NONMAGNETIC HEAVY-MINERAL-CONCENTRATE SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 6 OF AN 8-FACTOR R-MODE ANALYSIS


WALKER LAKE
AMMUNITION DEPOT
SODA SPRINGS VALLEY
TOIYABE
MONO VALLEY
A
B
C
D
E
F
G
H
Qa
QTb
QTa
Ta
Tt
Ts
Mz
Mzgr
Pz

Base from U.S. Geological Survey, 1957; revised 1969

MAP D. DISTRIBUTION OF SITES FOR NONMAGNETIC HEAVY-MINERAL-CONCENTRATE SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 7 OF AN 8-FACTOR R-MODE ANALYSIS

Geology simplified from Stewart and others, 1982

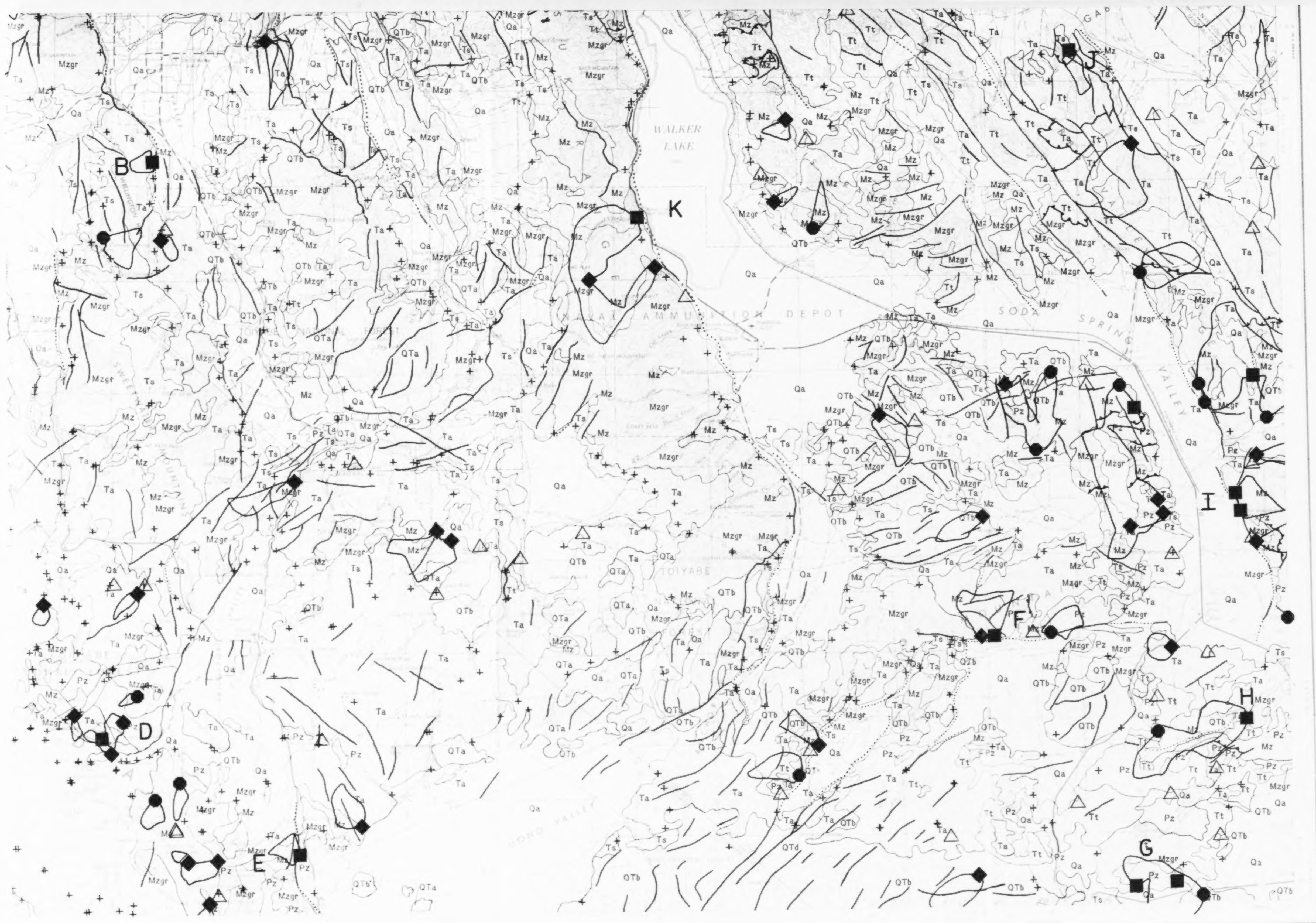
EXPLANATION

■ SAMPLE LOCALITY AND BOUNDAR
Anomalous for concentrate
loadings on factor 7. Loc
symbol. Square symbol ind
(98th percentile). Circle
next 5%, triangle, next 5%;
remaining 85%. Darkened s
significant sites

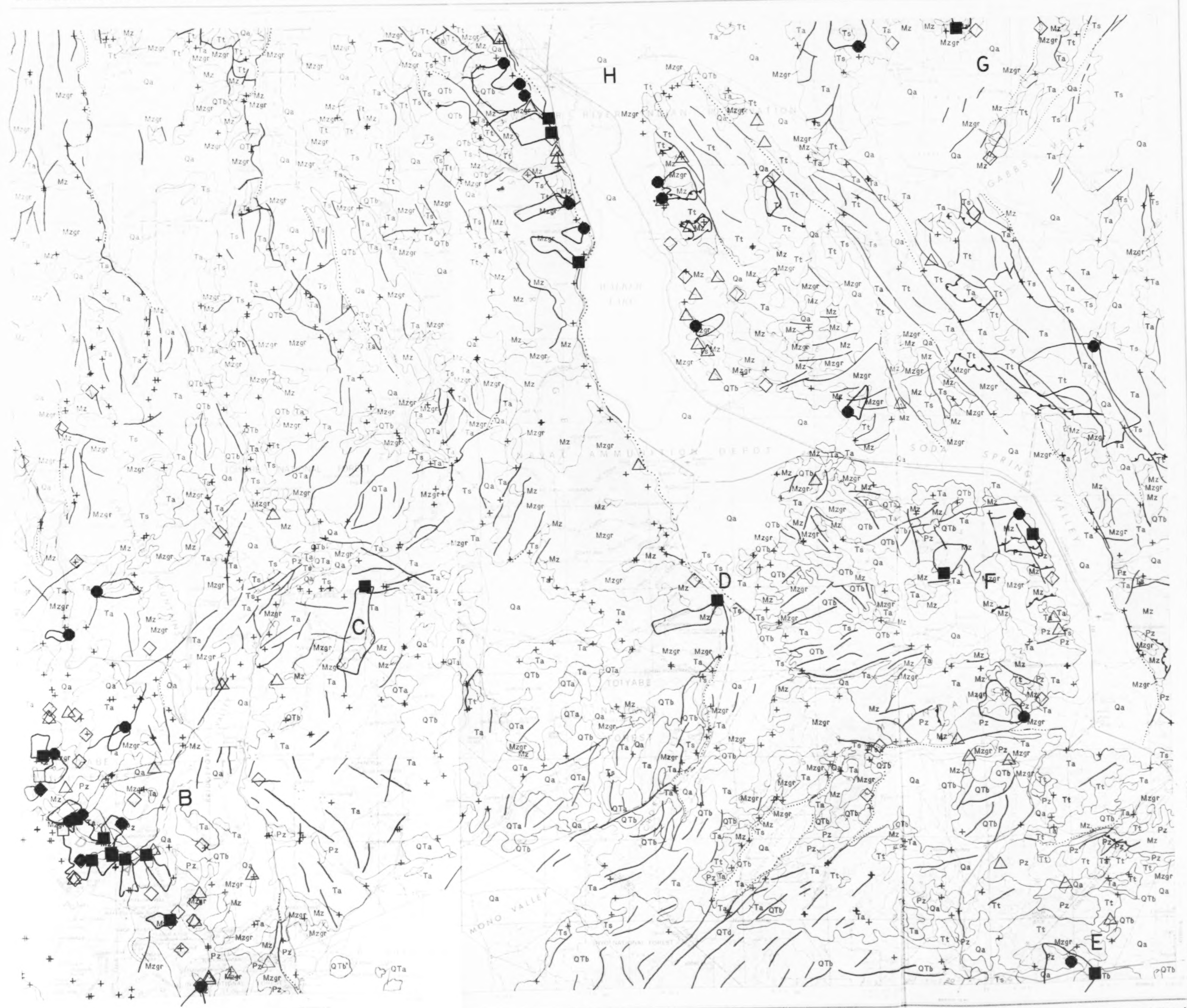
H SIGNIFICANT ANOMALOUS AREA
in text

MAPS SHOWING D
R-MODE FAC
ELEMENTS IN
SEDIMENT AN
WALKER LAKE

best copy available



C. DISTRIBUTION OF SITES FOR NONMAGNETIC HEAVY-MINERAL-CONCENTRATE SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 6 OF AN 8-FACTOR R-MODE ANALYSIS

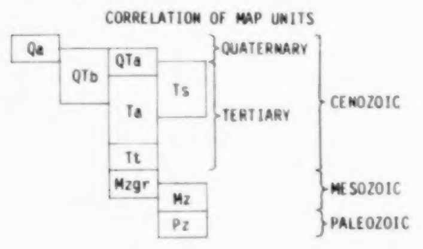


D. DISTRIBUTION OF SITES FOR NONMAGNETIC HEAVY-MINERAL-CONCENTRATE SAMPLES WITH SIGNIFICANT LOADINGS ON FACTOR 7 OF AN 8-FACTOR R-MODE ANALYSIS

Geology simplified from Stewart and others, 1982

Note: The following correlation and description of map units are for the geologic base map shown in gray

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qa	ALLUVIAL, LACUSTRINE, EOLIAN, LANDSLIDE, AND GLACIAL DEPOSITS, UNDIVIDED (QUATERNARY)--As mapped locally includes uppermost Tertiary gravel
QTb	BASALT (QUATERNARY AND TERTIARY)--Ranges in age from about 9 m.y. to less than 1 m.y.
QTa	ANDESITE TO RHYOLITE (QUATERNARY AND TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks. Ranges in age from about 5 m.y. to less than 1 m.y.
Ts	SEDIMENTARY ROCKS (TERTIARY)--Tuffaceous sandstone, siltstone, and conglomerate to gravel. Minor tuff and volcanic breccia. Ranges in age from about 12 m.y. to 2 m.y.
Ta	ANDESITE TO RHYOLITE (TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks, latitic to rhyolitic ash-flow tuffs, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from about 22 m.y. to 5 m.y.
Tt	TUFF (TERTIARY)--Welded and nonwelded rhyolitic ash-flow tuff. Minor rhyolite flows and shallow intrusive rocks, andesite flows, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from 30 m.y. to 22 m.y.
Mzg	GRANITIC ROCKS (MESOZOIC)--Granite to granodiorite. Minor dioritic, gabbroic, and felsic intrusive rocks
Mz	VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED (MESOZOIC)--Andesitic to rhyolitic lava flows, breccia, tuff, volcanic sandstone, and conglomerate; shallow marine siltstone, sandstone, conglomerate, and limestone; continental sandstone and conglomerate. Metamorphosed near granitic rocks
Pz	SEDIMENTARY AND VOLCANIC ROCKS, UNDIVIDED (PALEOZOIC)--Deep-water marine chert, phyllite, shale, carbonate rocks, volcanogenic turbidite, sandstone, and conglomerate (Ordovician, Devonian, Pennsylvanian, and Permian); shallow-water siltstone, sandstone, conglomerate, and carbonate (Cambrian, Mississippian, and Permian; as mapped includes upper Proterozoic rocks at one locality); and andesitic breccia and lava (Permian). Metamorphosed near granitic rocks

GEOLOGIC CONTACT

HIGH-ANGLE FAULT--Dotted where concealed

THRUST OR LOW-ANGLE FAULT

EXPLANATION

SAMPLE LOCALITY AND BOUNDARY OF ASSOCIATED DRAINAGE BASIN--Anomalous for concentrate samples with significant loadings on factor 7. Locality is at center of plotted symbol. Square symbol indicates upper 2% of the data (98th percentile). Circle symbol is next 3%; diamond, next 5%, triangle, next 5%; and plus symbol (+), remaining 85%. Darkened symbols identify the most significant sites

H SIGNIFICANT ANOMALOUS AREA OR SITE--Letter is keyed to list in text

NEVADA
CALIFORNIA

QUADRANGLE LOCATION

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

MAPS SHOWING DISTRIBUTION OF ANOMALIES BASED ON THE USE OF R-MODE FACTOR ANALYSIS FOR SELECTED GROUPINGS OF ELEMENTS IN SAMPLES OF MINUS-60-MESH (0.25-MM) STREAM SEDIMENT AND NONMAGNETIC HEAVY-MINERAL CONCENTRATE, WALKER LAKE 1° X 2° QUADRANGLE, CALIFORNIA AND NEVADA

By

M.A. Chaffee

1988

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1988

For sale by U.S. Geological Survey Map Distribution,
Box 25286, Federal Center, Denver, CO 80225